This document is a translation of the original document, written in Spanish for Comisión Estatal de Servicios Públicos de Tijuana (CESPT), the water and wastewater operating agency for the municipalities of Tijuana and Playas de Rosarito, Baja California, Mexico.

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Development and Evaluation of Integrated Alternatives

In Sections 7 and 8, the water supply options (sources) and the most relevant technological options for purification and sanitation in the study area were identified and prioritized. The water sources were prioritized based on the feasibility of their implementation. The purification options were evaluated based on the characteristics of each one of the water sources. Therefore, different technologies were chosen for each of the prioritized sources. Last of all, an option was chosen for sanitation based on the water quality criteria established for the planning process and other criteria.

In Sections 9 and 10, alternatives for water and sanitation were independently presented, beginning with the supply and technological options identified in the previous sections. The identified alternatives were given a preliminary evaluation in order to come up with a short list of the most feasible alternatives deserving of a more detailed evaluation. In this way, three alternatives for water and four alternatives for sanitation were obtained.

In this section, the alternatives for water and sanitation are combined to create global alternatives, which will include the interrelation between the water and sanitation systems.

The level of detail used for the prioritization of options and alternatives will be complemented in this section by the presentation of cost estimates, the size of the different projects, and an evaluation of alternatives.

12.1 Integration and Evaluation of Global Alternatives

Sections 7 and 8 identified the three alternatives for water supply sources and the four alternatives for sanitation shown in Table 12-1.

Table 12-1
Prioritized Water and Sanitation Alternatives

Water Alternatives	Sanitation Alternatives
Alternative B – Maximize desalination of seawater	Alternative B – Treatment plant in the Río Alamar area
Alternative F – Desalination of seawater together with indirect potable reuse	Alternative C – Treatment plants in the Río Alamar and coastal areas
Alternative G – Desalination of seawater, additional water from the Colorado River and indirect potable reuse	Alternative D – Treatment plant in the coastal area
	Alternative E – Treatment plant in the Río Alamar area and expansion of the La Morita plant

The various combinations of water and sanitation alternatives lead to the twelve global alternatives seen below in Table 12-2 and described in depth thereafter.

Table 12-2
Integrated Alternatives

Alternative	Description
B-B	Maximize desalination of seawater and construction of a wastewater treatment plant in the Río Alamar area
B-C	Maximize desalination of seawater and construction of wastewater treatment plants in the Río Alamar and coastal areas
B-D	Maximize desalination of seawater and construction of a wastewater treatment plant in the coastal area
B-E	Maximize desalination of seawater and construction of a wastewater treatment plant in the Río Alamar area and expansion of the La Morita WWTP
F-B	Desalination of seawater and indirect potable reuse; and construction of a wastewater treatment plant in the Río Alamar area
F-C	Desalination of seawater and indirect potable reuse; and construction of wastewater treatment plants in the Río Alamar and coastal area
F-D	Desalination of seawater and indirect potable reuse; and construction of a wastewater treatment plant in the coastal area
F-E	Desalination of seawater and indirect potable reuse; and construction of a wastewater treatment plant in the Río Alamar area and the expansion of the La Morita WWTP
G-B	Desalination of seawater, additional water from the Colorado River and indirect potable reuse; and construction of a wastewater treatment plant in the Río Alamar area
G-C	Desalination of seawater, additional water from the Colorado River and indirect potable reuse; and construction of a wastewater treatment plant in the Río Alamar area and in the coastal area
G-D	Desalination of seawater, additional water from the Colorado River and indirect potable reuse; and construction of a wastewater treatment plant in the coastal area
G-E	Desalination of seawater, additional water from the Colorado River and indirect potable reuse; and construction of a wastewater treatment plant in the Río Alamar area and expansion of the La Morita WWTP

Public Law 106-457, described in Section 8.7 and mentioned in Section 9, constitutes a scenario for analysis for the three best performing alternatives of the master plan.

Alternative B-B – Maximize the desalination of seawater and the construction of a wastewater treatment plant in the Río Alamar area

Described below are the principal components of each alternative for the water and sanitation systems that were presented in Figure 12-1.

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Figure 12-1
Alternative B-B

Potable Water

In this alternative we propose to counterbalance the deficit of potable water projected for the year 2023 through the construction of a desalination plant based on reverse osmosis with a capacity of 3,225 L/s. The El Florido and Abelardo L. Rodríguez water treatment plants will continue operating, after renovation, to treat water coming from the Colorado River. The Colorado River aqueduct will be renovated by the State Water Services Commission (COSAE) to supply CESPT with 4,500 L/s. This water will first be stored in the El Carrizo reservoir; from there, it can be taken for treatment to the El Florido plant, or else sent to the Abelardo L. Rodríguez reservoir for storage. The water stored in the Abelardo L. Rodríguez reservoir will be purified in the Abelardo L. Rodríguez Plant.

The water production infrastructure will be built to meet the maximum daily water demand, which is equal to the average daily demand multiplied by 1.2. However, the average production is used to estimate the operation and maintenance costs from Section 12.3. Table 12-3 shows the various projects that make up this Alternative.

Average daily capacity for each plant

Table 12-3
Potable Water Projects for Alternative B-B

Project	Water source	Maximum capacity (l/s)	Average operational flow (l/s)
Base Infrastructure:			
El Florido water treatment plant	Colorado River	4,000	4000
Abelardo L. Rodríguez water treatment plant	Colorado River	500	500
Río Alamar/Río Tijuana aquifer wells	Tijuana/Alamar Aquifer	180	180
Monte de los Olivos water treatment plant	Tijuana/Alamar Aquifer	250	250
La Misión wells	La Misión aquifer	51	51
Proposed infrastructure:			
Desalination Plant	Pacific Ocean	3,225	1,857
Total Supply		**8,206**	
Average daily demand			6,838
Maximum daily demand		8,206	

In addition to the water treatment plants and the water production projects, this alternative includes the construction of a seawater main to the new desalination plant with a length of 1,950 meters and a diameter of 183 cm; the construction of 13 master tanks with capacities of 500 to 20,000 m^3; 78,800 meters of water mains with diameters of 30 to 152 cm; 7 pumping plants with capacities of 100 to 12,000 hp; the construction of 270,000 meters of supply pipelines with diameters of 10 to 46 cm to increase the coverage of potable water service to 100% of the population; the construction of 1,420,200 meters of supply pipelines with diameters of 10 to 46 cm of the primary network to provide service to the future growth areas; and the renovation of 247,600 meters of supply pipelines in poor condition with diameters of 5 to 46 cm.

Sanitation

The sanitation of wastewater would take place in 12 treatment plants (see Table 12-4), three of the plants are already in operation, four will be constructed by CESPT before 2005 as part of the *Crédito Japonés* (Japanese Credit) program, and the five remaining are proposed as part of this alternative. As mentioned in Section 8, the new plants will provide secondary treatment through an activated sludge process.

Table 12-4
Sanitation Projects for Alternative B-B

Project	Locations served	Average Capacity (l/s)
Base Infrastructure:		
International Plant	Tijuana	1,100
San Antonio de los Buenos	Tijuana	1,100
Rosarito I	Playas de Rosarito	50
Crédito Japonés plants:		
La Morita	Tijuana	380
Monte de Los Olivos	Tijuana	460
Tecolote-La Gloria	Tijuana	380
Rosarito II	Playas de Rosarito, Tijuana	210
Proposed Infrastructure:		
Alamar Regional	Tijuana	1,470
Rosarito I expansion	Playas de Rosarito	70
Popotla	Popotla, Calafia, South of Playas de Rosarito	130
Mesa del Descanso	Mesa del Descanso	20
Puerto Nuevo	Puerto Nuevo, Primo Tapia	20
La Misión	Santa Anita	10
Total Supply		**5,400**
Average daily demand		5,385

Unlike the water treatment and production plants, the wastewater treatment plants are built based on the average amount of wastewater generated.

An important component of the sanitation infrastructure are the pumping projects and the wastewater transport from the sewer system to the treatment plants, as well as the effluent mains from the plants to the discharge site. All the plants will discharge into the Pacific Ocean, either in Mexican territory, or in the United States through The South Bay Ocean Outfall, property of the city of San Diego and the USIBWC. Table 12-5 summarizes the principal piping projects.

Table 12-5			
Main Wastewater and Effluent Conveyance Pipeline Projects for Alternative B-B			
Treatment Plant	**Pumping (hp)**	**Conveyance Line**	
		Longitude (m)	**Diameter (cm)**
Raw Wastewater:			
Regional Alamar	4,950	10,800	142
Rosarito I	280	3,700	36
Popotla	60	6,300	20
Mesa del Descanso	60	12,800	20
Puerto Nuevo	60	7,300	20
La Misión	10	1,300	20
Effluent:			
Monte de los Olivos, La Morita and Alamar	Gravity	38,800	45 to 213
Tecolote- La Gloria	Gravity	500	91
Rosarito II	Gravity	500	61
Popotla	Gravity	500	25
Mesa del Descanso	Gravity	500	25
Puerto Nuevo	Gravity	500	25
La Misión	Gravity	500	25

The Monte de los Olivos, La Morita, and Alamar Regional plants have shared infrastructure for the handling of the effluent, which will then be transported to the San Diego ocean outfall for its disposal. The first pipeline will transport the effluent from the La Morita and Los Olivos plants up to a point near the convergence of the Tijuana and Alamar rivers, where it will join with the pipeline from the Alamar plant. From that point on, there will be a single pipeline crossing to the United States and connecting to South Bay Ocean Outfall.

Finally, 172,500 meters of primary sewer lines will be constructed; 908,400 meters of secondary sewer lines (with diameters of 20 to 30 cm) will increase the service coverage to 100% of the population; 1,163,800 meters of sewer lines (with diameters of 20 to 30 cm) will be constructed to satisfy the demands created by future growth; and 618,600 meters of existing sewer lines that are in poor condition (with diameters of 20 to 30 cm) will be renovated.

Alternative B-C – Maximize the desalination of seawater and construction of wastewater treatment plants in the Río Alamar and coastal areas

Potable water

Alternative B-C is identical to alternative B-B with respect to the potable water system. Refer to the previous section for the description of the potable water projects.

Sanitation

The main difference between this alternative and the previous one is that the wastewater generated in the city of Tijuana will be treated in two treatment plants: the previously described Alamar Regional plant and an additional plant located in the coastal area. The rest of the plants will be the same as those from Alternative B-B. In Table 12-6 the proposed treatment plants for this alternative are presented. In Figure 12-2, this alternative is shown graphically.

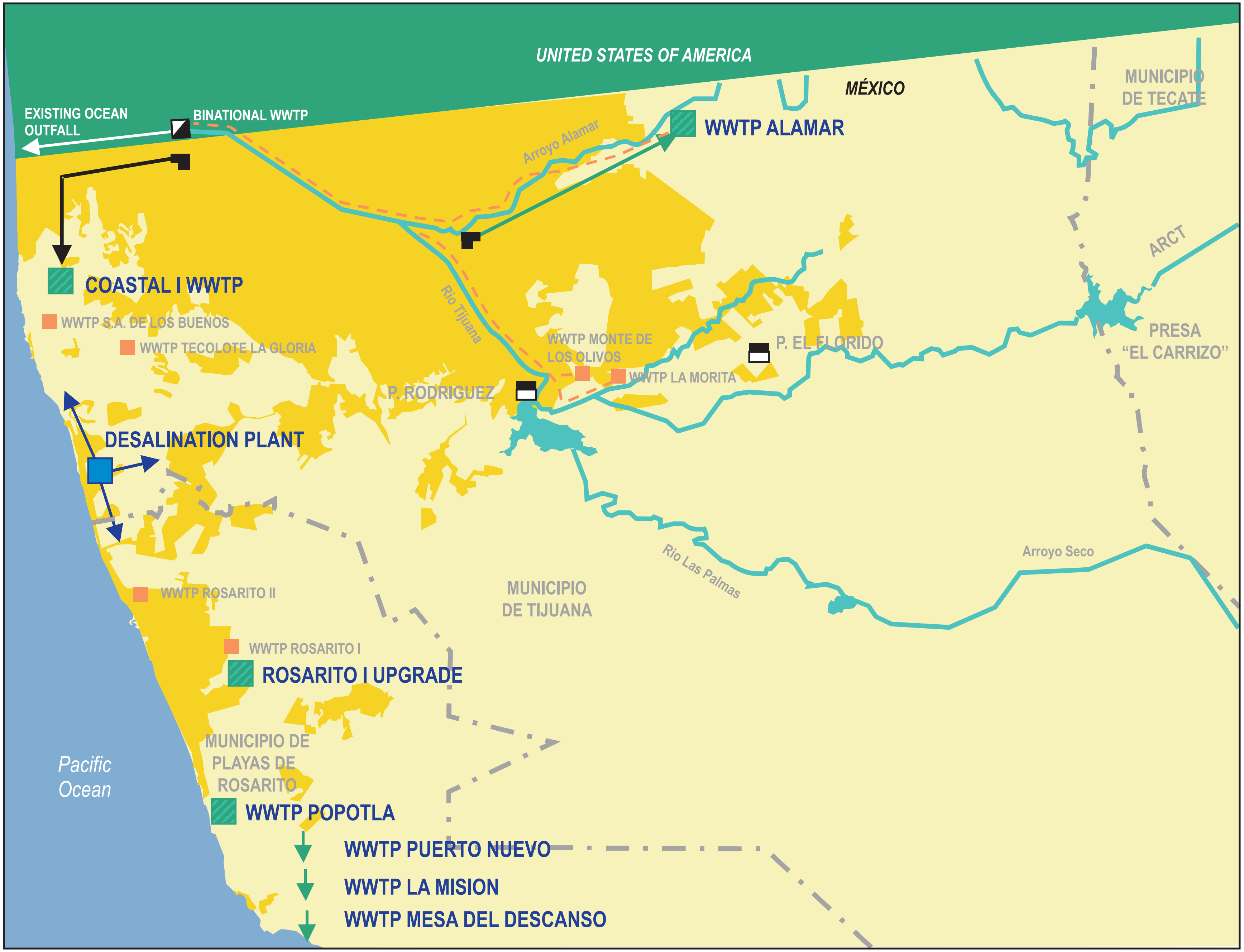

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Figure 12-2
Alternative B-C

Table 12-6
Sanitation Projects for Alternative B-C

Project	Locations served	Average Capacity (L/s)
Base Infrastructure:		
International Plant	Tijuana	1,100
San Antonio de los Buenos	Tijuana	1,100
Rosarito I	Playas de Rosarito	50
Crédito Japonés plants:		
La Morita	Tijuana	380
Monte de Los Olivos	Tijuana	460
Tecolote-La Gloria	Tijuana	380
Rosarito II	Playas de Rosarito, Tijuana	210
Proposed Infrastructure:		
Alamar Regional	Tijuana	1,090
Coastal Regional	Tijuana	380
Rosarito I expansion	Playas de Rosarito	70
Popotla	Popotla, Calafia, South of Playas de Rosarito	130
Mesa del Descanso	Mesa del Descanso	20
Puerto Nuevo	Puerto Nuevo, Primo Tapia	20
La Misión	Santa Anita	10
Total supply		**5,400**
Average daily demand		5,385

Table 12-7 summarizes the principal piping projects. The only difference between this alternative and the previous one is the necessary infrastructure to pipe wastewater to the coastal regional plant.

Table 12-7
Main Wastewater and Effluent Conveyance Pipeline Projects for Alternative B-C

Treatment Plant	Pumping (hp)	Conveyance Line	
		Longitude (m)	Diameter (cm)
Raw Wastewater:			
Regional Alamar	3,600	10,800	122
Coastal Regional	2,400	4,600	61
Rosarito I	280	3,700	36
Popotla	60	6,300	20
Mesa del Descanso	60	12,800	20
Puerto Nuevo	60	7,300	20
La Misión	10	1,300	20
Effluent:			
Monte de los Olivos, La Morita and Alamar	Gravity	38,800	45 to 213
Tecolote- La Gloria	Gravity	500	91
Rosarito II	Gravity	500	61
Popotla	Gravity	500	25
Mesa del Descanso	Gravity	500	25
Puerto Nuevo	Gravity	500	25
La Misión	Gravity	500	25

It is assumed that the effluent mains from the coastal regional plant to the sea for discharge will be relatively small; therefore they are included as part of the plant.

Similar to the previous alternative, this alternative includes the construction of 172,500 meters of primary sewer lines; and 908,400 meters of secondary sewer lines to increase the service coverage to 100% of the population; the construction of 1,163,800 meters of sewer lines to satisfy the demands created by future growth; and the renovation of 618,600 meters of existing sewer lines that are in poor condition.

Alternative B-D – Maximize the desalination of seawater and the construction of a wastewater treatment plant in the coastal area

Potable water

Alternative B-D is identical to Alternatives B-B and B-C with respect to the potable water system. See the previous sections for the descriptions of the potable water projects.

Sanitation

Just as in Alternative B-B, the sanitation in Alternative B-D is achieved through 12 treatment plants. However, for Alternative B-D the regional plant for the city of Tijuana is located in the coastal area instead of in the Río Alamar area. See Figure 12-3.

Table 12-8 shows the proposed treatment plants for this alternative.

Table 12-8
Sanitation Projects for Alternative B-D

Project	Locations served	Average Capacity (L/s)
Base Infrastructure:		
International Plant	Tijuana	1,100
San Antonio de los Buenos	Tijuana	1,100
Rosarito I	Playas de Rosarito	50
Crédito Japonés plants:		
La Morita	Tijuana	380
Monte de Los Olivos	Tijuana	460
Tecolote-La Gloria	Tijuana	380
Rosarito II	Playas de Rosarito, Tijuana	210
Proposed Infrastructure:		
Coastal Regional	Tijuana	1,470
Rosarito I expansion	Playas de Rosarito	70
Popotla	Popotla, Calafia, South of Playas de Rosarito	130
Mesa del Descanso	Mesa del Descanso	20
Puerto Nuevo	Puerto Nuevo, Primo Tapia	20
La Misión	Santa Anita	10
Total Supply		**5,400**
Average daily demand		5,385

Figure 12-3
Alternative B-D

Table 12-7 summarizes the principal piping projects. The only difference between this alternative and the previous one is the infrastructure necessary to transport wastewater to the coastal regional plant.

Table 12-9			
Main Wastewater and Effluent Conveyance Pipeline Projects for Alternative B-D			
Treatment Plant	**Pumping (hp)**	**Conveyance Line**	
		Longitude (m)	**Diameter (cm)**
Raw Wastewater:			
Coastal Regional	2,000	27,600	142 to 400
Rosarito I	280	3,700	36
Popotla	60	6,300	20
Mesa del Descanso	60	12,800	20
Puerto Nuevo	60	7,300	20
La Misión	10	1,300	20
Effluent:			
Monte de los Olivos and La Morita	Gravity	27,000	45 to 122
Tecolote- La Gloria	Gravity	500	91
Rosarito II	Gravity	500	61
Popotla	Gravity	500	25
Mesa del Descanso	Gravity	500	25
Puerto Nuevo	Gravity	500	25
La Misión	Gravity	500	25

The raw wastewater main will be made up of a gravity-operated pipeline 6,500 meters long that will originate near the convergence of the Tijuana and Alamar rivers and will flow to a point near pumping plant PB-1. There, it will connect with an 11,500-meter-long tunnel that will also be gravity operated and will cross the hills that separate the Tijuana basin from the coastal basins. On leaving the tunnel, the main will have a pressurized pipeline 9,600 meters in length and a 2,000-horse power pumping station.

Similar to the previous alternatives, this one includes the construction of 172,500 meters of primary sewer lines; 908,400 meters of secondary sewer lines to increase the coverage to 100% of the population; the construction of 1,163,800 meters of sewer lines to satisfy the demands created by future growth; and the renovation of 618,600 meters of existing sewer lines that are in poor condition.

Alternative B-E – Maximize the desalination of seawater and construction of a wastewater treatment plant in the Río Alamar area and the expansion of the La Morita WWTP

Potable water

The potable water system for alternative B-E is identical to the three previous Alternatives (B-B, B-C and B-D).

Sanitation

Alternative B-E is very similar to Alternative B-B. The difference is that the Alamar Regional plant will be smaller, while the La Morita *Crédito Japonés* plant will be expanded to compensate for the reduction in size of the Alamar Regional plant. This alternative will have fewer wastewater pumping requirements, since the elevation head between the point of interception and La Morita is less than the elevation head between the point of interception and the Alamar plant. Figure 12-4 shows this alternative, while the Table 12-10 lists the various sanitation projects for this alternative.

Table 12-10
Sanitation Projects for Alternative B-E

Project	Areas served	Average capacity (L/s)
Base Infrastructure:		
International Plant	Tijuana	1,100
San Antonio de los Buenos	Tijuana	1,100
Rosarito I	Playas de Rosarito	50
Crédito Japonés plants:		
La Morita	Tijuana	380
Monte de Los Olivos	Tijuana	460
Tecolote-La Gloria	Tijuana	380
Rosarito II	Playas de Rosarito, Tijuana	210
Proposed Infrastructure:		
Alamar Regional	Tijuana	980
La Morita expansion	Tijuana	490
Rosarito I expansion	Playas de Rosarito	70
Popotla	Popotla, Calafia, South of Playas de Rosarito	130
Mesa del Descanso	Mesa del Descanso	20
Puerto Nuevo	Puerto Nuevo, Primo Tapia	20
La Misión	Santa Anita	10
Total Supply		**5,400**
Average daily demand		5,385

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Figure 12-4
Alternative B-E

Table 12-11 summarizes the principal piping projects. The only difference between this alternative and Alternative B-B is the necessary infrastructure to transport additional wastewater to the La Morita plant.

Table 12-11
Main Wastewater and Effluent Conveyance Pipeline Projects for Alternative B-E

Treatment Plant	Pumping (hp)	Conveyance Line	
		Longitude (m)	Diameter (cm)
Raw Wastewater:			
Regional Alamar	3,250	10,793	122
La Morita Expansion	750	3,000	76
Rosarito I	280	3,700	36
Popotla	60	6,300	20
Mesa del Descanso	60	12,800	20
Puerto Nuevo	60	7,300	20
La Misión	10	1,300	20
Effluent:			
Monte de los Olivos, La Morita and Alamar	Gravity	38,300	45 to 213
Tecolote- La Gloria	Gravity	500	91
Rosarito II	Gravity	500	61
Popotla	Gravity	500	25
Mesa del Descanso	Gravity	500	25
Puerto Nuevo	Gravity	500	25
La Misión	Gravity	500	25

Similar to the previous alternatives, the construction of 172,600 meters of primary sewer lines; 908,400 meters of secondary sewer lines to increase the service coverage to 100% of the population; the construction of 1,163,800 meters of sewer lines to satisfy the demands created by future growth; and the renovation of 618,600 meters of existing sewer lines that are in poor condition are included.

Alternative F-B – Desalination of seawater and indirect potable reuse; and construction of a wastewater treatment plant in the Río Alamar area

Potable water

In this alternative we propose to counterbalance the deficit of potable water projected for the year 2023 through the construction of a desalination plant and the implementation of a program of indirect potable reuse. With this plan, the desalination plant will have a maximum capacity 2,450 L/s, while the reuse will provide up to 775 L/s.

The program of indirect potable reuse will consist of the advanced treatment of part of the secondary effluent from La Morita, Monte de los Olivos and Alamar Regional treatment plants through a process of microfiltration and reverse osmosis. The advanced effluent from the two first plants will be transported upstream to the Abelardo L. Rodríguez reservoir, where the effluent will finally be stored. While it is stored in the reservoir, the effluent could be mixed with water from the Colorado

River or with surface runoff; therefore its quality could be modified. The water extracted from the reservoir will be treated through a conventional purification process before being sent to the distribution network. On the other hand, the advanced effluent from the Alamar Regional plant will be recharged to the Río Alamar aquifer. The recharged water will be mixed with the underground aquifer water and will be extracted at a point downstream.

It is estimated that approximately 70 percent of the secondary effluent treated in the microfiltration and osmosis process will be recovered as high-quality effluent, while the remaining 30 percent will be thrown out with the secondary effluent that is not considered for reuse. Additionally, for planning reasons it can be assumed that 80 percent of the recharged water from the reservoir will be recoverable for purification and that the remaining 20 percent will be lost through evaporation and infiltration. Similarly, it is estimated that approximately 70 percent of the water recharged to the aquifer will be recovered for reuse. In this way, 56 percent of the effluent from the La Morita and Monte de los Olivos plants can be reused, while 56 percent of the effluent from the Alamar Regional plant could also be reused.

Similar to the previous alternatives, the El Florido and Abelardo L. Rodríguez water treatment plants will remain in operation, after renovation, to treat water coming from the Colorado River with a capacity of 4,500 L/s.

Table 12-12 and Figure 12-5 show the different projects in this alternative.

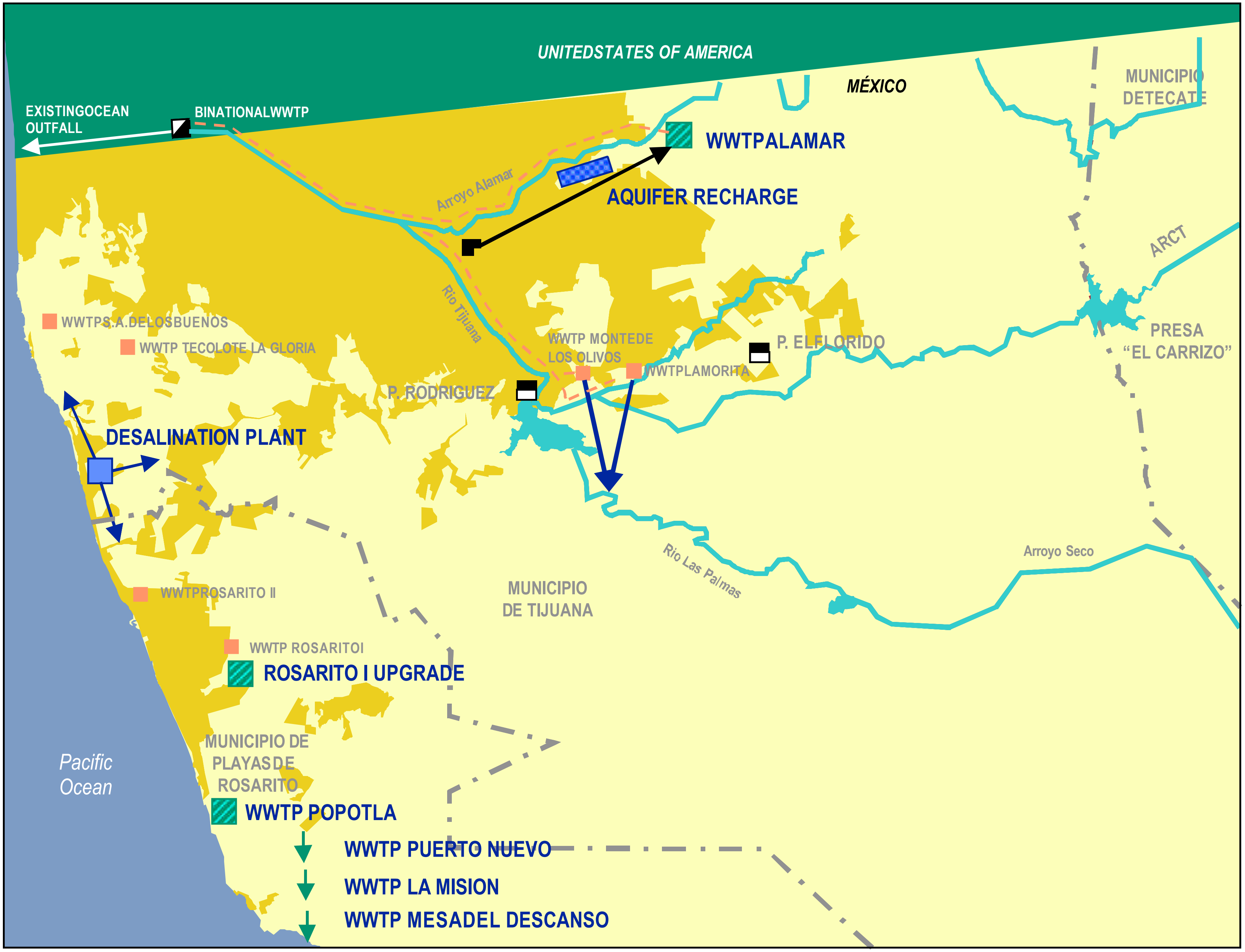

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Figure 12-5
Alternative F-B

Table 12-12
Potable Water Projects for Alternative F-B

Project	Water Source	Maximum Capacity (L/s)	Average operational flow (L/s)
Base Infrastructure:			
El Florido water treatment plant	Colorado River	4,000	4,000
Abelardo L. Rodríguez water treatment plant	Colorado River	500	500
Río Alamar/Río Tijuana aquifer wells	Tijuana/Alamar Aquifer	180	180
Monte de los Olivos water treatment plant	Aquifer Tijuana/Alamar	250	250
La Misión wells	La Misión wells	51	51
Proposed Infrastructure:			
Desalination Plant	Pacific Ocean	2,450	1,082
Microfiltration/reverse osmosis at La Morita and Monte de los Olivos (1) WWTPs	Effluent from La Morita and Monte de los Olivos WWTP	588	588
Microfiltration/reverse osmosis at Alamar Regional (1) WWTP	Effluent from Alamar Regional WWTP	420	420
New wells (Extraction of the aquifer recharge)	Alamar Aquifer	300	300
Water treatment plant for reuse flows from the Rodríguez reservoir	Effluent from the La Morita and Monte de los Olivos WWTPs	475	475
Total supply		**8,206**	
Average daily demand			6,838
Maximum daily demand		8,206	

(1) Not all the effluent treated through microfiltration and reverse osmosis is recovered for reuse due to the estimated efficiency of the process. The quantity of water that can be used corresponds to the new extraction wells (300 l/s) and to the treatment plant for reuse flows (475 l/s).

As previously mentioned, the desalination plant is built to meet the maximum daily demand for water. However, to estimate the operation and maintenance costs, an average daily flow is used. On the other hand, the infrastructure for reuse is built to meet only the average daily flow, and it is assumed that the peaks in demand will be satisfied by other sources.

Table 12-13 shows the necessary infrastructure for the transport of effluent for the system of indirect potable reuse.

Table 12-13
Infrastructure for the Pipelines of Effluent for Indirect Potable Reuse Under Alternative F-B

Treatment Plant	Pumping (hp)	Conveyance Lines	
		Longitude (m)	Diameter (cm)
From Monte de los Olivos to La Morita WWTP [1]	1,900	6,500	76
From La Morita WWTP to the upstream recharge site of the Abelardo L. Rodríguez Reservoir	1,144	9,200	61
From Alamar Regional WWTP to the site for aquifer recharge	1,206	2,200	61

[1] The secondary effluent from La Morita for reuse will be sent to Monte de los Olivos, where the microfiltration/reverse osmosis process will take place for the secondary effluent of both plants.

Injection wells from the Río Alamar aquifer with a capacity of 420 L/s and a series of extraction wells with capacities of 300 L/s will be constructed. The number of wells and their placement will be determined through a specific study of the aquifer characteristics.

In addition to the purification plants and the water production and reuse projects, this alternative includes the construction of a seawater main to the new desalination plant with a length of 1,950 meters and a diameter of 152 cm; the construction of 13 master tanks with capacities ranging from 500 to 20,000 m^3; 89,660 meters of water mains with diameters from 30 cm to 152 cm; 10 pumping plants with capacities from 100 to 7,600 hp; the construction of 270,000 meters of supply pipelines with diameters from 10 to 46 cm to increase service coverage of potable water to 100 percent of the population; the construction of 1,420,100 meters of supply pipelines from the primary network to service the areas of future growth; and the renovation of 247,600 meters of supply pipelines that are in poor condition.

Sanitation
The components of the sanitation system for this alternative are identical to those shown as part of alternative B-B.

Alternative F-C – Desalination of seawater and indirect potable reuse; and construction of wastewater treatment plants in the Río Alamar and coastal areas

Potable water
The components of the potable water system for this alternative are identical to those in Alternative F-B. (See Figure 12-6)

Sanitation
The sanitation components of this alternative are identical to those in Alternative B-C.

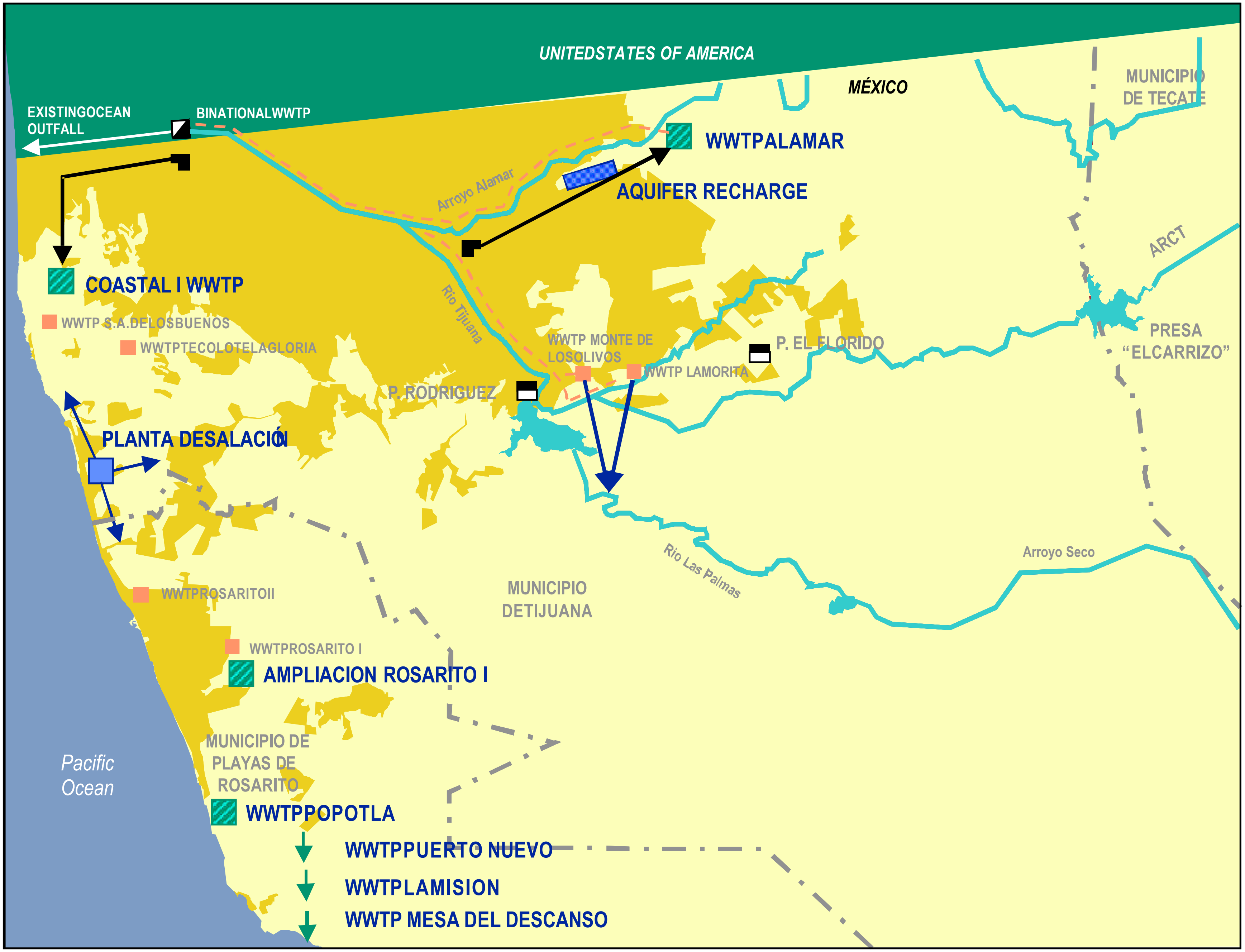

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Figure 12-6
Alternative F-C

Alternative F-D – Desalination of seawater and indirect potable reuse; and construction of a wastewater treatment plant in the coastal area

Potable water

The only difference between this alternative and the previous two is that the quantity of indirect potable reuse will be reduced, since there is no regional wastewater treatment plant in the basin of the Río Tijuana. The secondary effluent from the La Morita and Monte de los Olivos plants will be treated through a process of filtration and reverse osmosis for its recharge into the Abelardo L. Rodríguez reservoir. The effluent from the Coastal WTP will be discharged into the sea.

The reduction in the amount of indirect potable reuse will be compensated with additional desalination capacity. With this plan, the desalination plant will have a maximum capacity of 2,750 L/s, a little greater than the previous alternatives, while the reuse will provide 475 L/s.

Similar to the previous alternatives, the El Florido and Abelardo L. Rodríguez water treatment plants will keep operating, after renovation, to treat water coming from the Colorado River with a capacity of 4,500 L/s.

Table 12-14 and Figure 12-7 show the various projects that comprise this alternative.

Table 12-14
Potable Water Projects for Alternative F-D

Project	Source of water	Maximum Capacity (L/s)	Average Operational Flow (L/s)
Base Infrastructure:			
El Florido water treatment plant	Colorado River	4,000	4,000
Abelardo L. Rodríguez water treatment plant	Colorado River	500	500
Río Alamar/Río Tijuana Aquifer wells	Tijuana/Alamar Aquifer	180	180
Monte de los Olivos water treatment plant	Tijuana/Alamar Aquifer	250	250
La Misión wells	La Misión Aquifer	51	51
Proposed infrastructure:			
Desalination Plant	Pacific Ocean	2,750	1,382
Microfiltration/reverse osmosis at La Morita and Monte de los Olivos WWTPs (1)	Effluent from La Morita and Monte de los Olivos WWTPs	588	588
Water treatment plant for the reuse flows from the Rodríguez reservoir	Effluent from La Morita and Monte de los Olivos WWTPs	475	475
Total supply		**8,206**	
Average daily demand			6,838
Maximum daily demand		8,206	

1) Not all the effluent treated through microfiltration and reverse osmosis is recovered for reuse due to the estimated efficiency of the process. The quantity of water that can be used corresponds to the new extraction wells (300 l/s) and to the treatment plant for reuse flows (475 l/s).

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Figure 12-7
Alternative F-D

As previously mentioned, the desalination plant is built to satisfy the maximum daily demand for water, although to estimate the operation and maintenance costs an average daily operational flow is used. On the other hand, the reuse infrastructure is built to meet only the average daily flow, and it is assumed that the peaks in demand are satisfied by other sources.

Table 12-15 shows the necessary infrastructure for the conveyance of effluent for the indirect potable reuse system.

Table 12-15
Infrastructure for the Pipelines of Effluent for Indirect Potable Reuse Under Alternative F-D

Treatment Plant	Pumping (hp)	Conveyance Lines	
		Longitude (m)	Diameter (cm)
From Monte de los Olivos to La Morita WWTP [(1)]	1,900	6,500	76
From La Morita WWTP to the upstream recharge site of the Abelardo L. Rodríguez Reservoir	1,144	9,200	61

[1] The secondary effluent from La Morita for reuse will be sent to Monte de los Olivos, where the microfiltration/reverse osmosis process will take place for the secondary effluent of both plants.

In addition to the water treatment plants and the water production and reuse projects, this alternative includes the construction of a seawater main to the new desalination plant with a length of 1,950 meters and a diameter of 152 cm; the construction of 13 master tanks with capacities from 500 to 20,000 m^3; 89,700 meters of water mains with diameters from 30 to152 cm; 10 pumping plants with capacities from 100 to 7,200 hp; the construction of 270,000 meters of supply pipelines with diameters from 10 to 46 cm to increase service coverage of potable water to 100% of the population; the construction of 1,420,100 meters of supply pipelines from the primary network to service the areas of future growth; and the renovation of 247,600 meters of supply pipelines that are in poor condition.

Sanitation:
The components of the sanitation system for this alternative are identical to those in alternative B-D.

Alternative F-E – Desalination of seawater and indirect potable reuse; and construction of a wastewater treatment plant in the Río Alamar area and the expansion of the La Morita WWTP

Potable water:
The components of the water system of this alternative are very similar to those in Alternative F-B, with the difference that the expansion of the La Morita wastewater treatment plant will allow for an increase in the amount of indirect potable reuse through discharge into the Abelardo L. Rodríguez reservoir. This will allow the capacity of the desalination plant to be reduced. The amount of indirect potable reuse

of the effluent from the Alamar Regional plant will stay the same. As part of this alternative, the projected potable water deficit for the year 2023 would be made up through the construction of a desalination plant and the implementation of an indirect potable reuse program. Under this plan, the desalination plant will have a maximum capacity of 2,170 L/s, while the reuse will provide up to 1,051 L/s. Table 12-16 shows the various projects that make up this alternative. (See Figure 12-8)

Table 12-16
Potable Water Projects for Alternative F-E

Project	Water source	Maximum Capacity (L/s)	Average operational flow (L/s)
Base Infrastructure:			
El Florido water treatment plant	Colorado River	4,000	4,000
Abelardo L. Rodríguez water treatment plant	Colorado River	500	500
Río Alamar/Río Tijuana aquifer wells	Tijuana/Alamar Aquifer	180	180
Monte de los Olivos water treatment plant	Tijuana/Alamar Aquifer	250	250
La Misión wells	La Misión Aquifer	51	51
Proposed Infrastructure:			
Desalination Plant	Pacific Ocean	2,170	806
Microfiltration/reverse osmosis at La Morita and Monte de los Olivos (1) WWTPs	Effluent from La Morita and Monte de los Olivos WWTPs	931	931
Microfiltration/reverse osmosis at Alamar Regional (1) WWTP	Effluent from Alamar Regional WWTP	600	600
New wells (Extraction of the aquifer recharge)	Alamar Aquifer	300	300
Water treatment plant for the reuse flows from the Rodríguez reservoir	Effluent from the La Morita and Monte de los Olivos WWTPs	751	751
Total Supply		**8,202**	
Average daily demand			6,838
Maximum daily demand		8,206	

1) Not all the effluent treated through microfiltration and reverse osmosis is recovered for reuse due to the estimated efficiency of the process. The quantity of water that can be used corresponds to the new extraction wells (300 l/s) and to the treatment plant for reuse flows (475 l/s).

Table 12-17 shows the necessary infrastructure for the transport of effluent for the indirect potable reuse system.

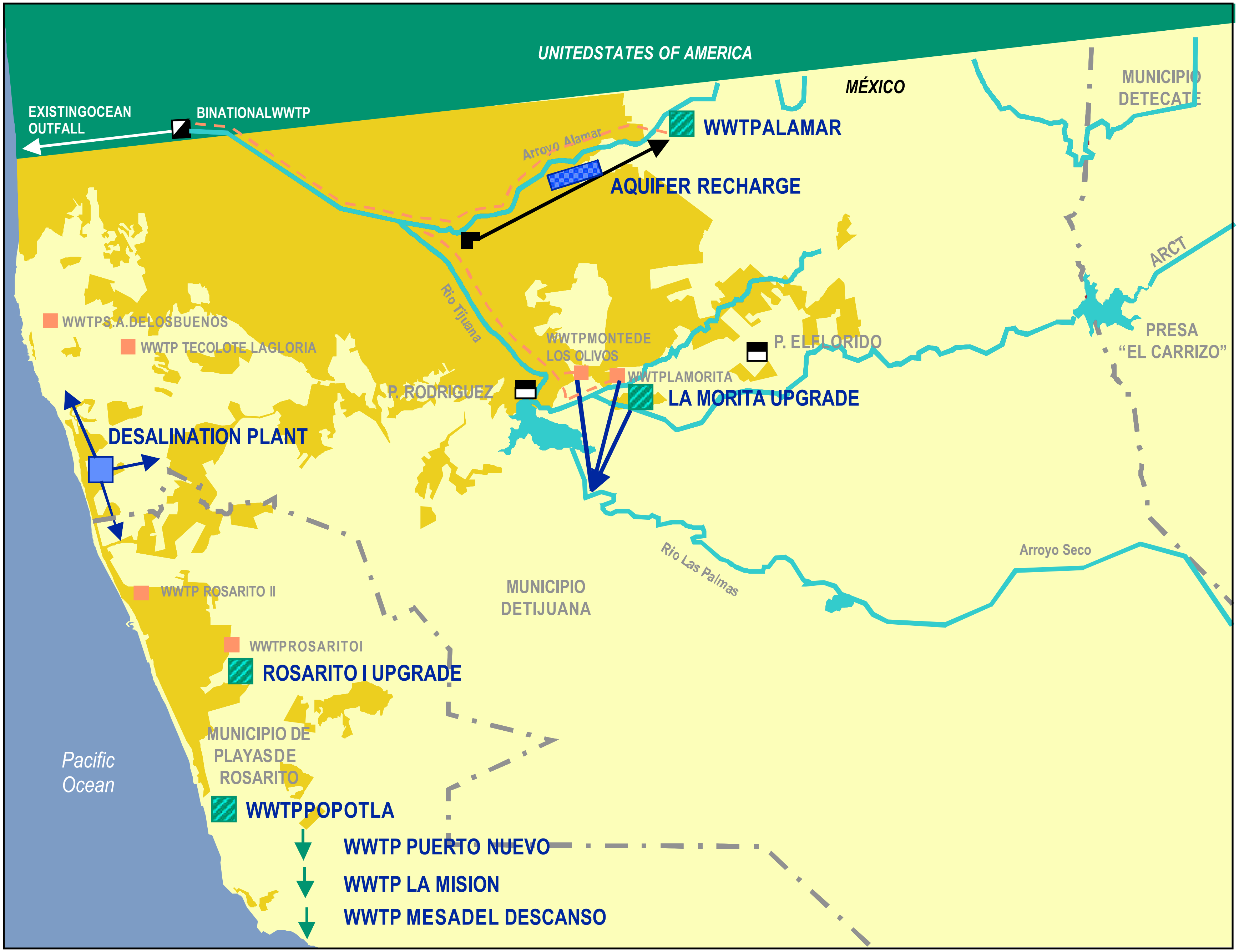

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Figure 12-8
Alternative F-E

Table 12-17
Infrastructure for the Pipelines of Effluent for Indirect Potable Reuse Under Alternative F-E

Treatment Plant	Pumping (hp)	Conveyance Lines	
		Longitude (m)	Diameter (cm)
From Monte de los Olivos to La Morita WWTP [1]	1,900	6,500	76
From La Morita WWTP to the upstream recharge site of the Abelardo L. Rodríguez Reservoir	1,144	9,200	61
From Alamar Regional WWTP to the site for aquifer recharge	1,206	2,200	61

[1] The secondary effluent from La Morita for reuse will be sent to Monte de los Olivos, where the microfiltration/reverse osmosis process will take place for the secondary effluent of both plants.

Injection wells from the Río Alamar aquifer with a capacity of 420 L/s and a series of extraction wells of 300 L/s will be constructed. The number and placement of the wells will be determined through a specific study of the aquifer characteristics.

In addition to the water treatment plants and the water production and reuse projects, this alternative includes the construction of a seawater main to the new desalination plant with a length of 1,950 meters and a diameter of 152cm; the construction of 13 master tanks with capacities from 500 to 20,000 m^3; 89,700 meters of water mains with diameters from 30 to 152 cm; 10 pumping plants with capacities ranging from 100 to 7,200 hp; the construction of 270,000 meters of supply pipelines with diameters from 10 to 46 cm to increase service coverage of potable water to 100 percent of the population; the construction of 1,420,100 meters of supply pipelines from the primary network to service the future growth areas; and the renovation of 247,600 meters of supply pipelines that are in poor condition.

Sanitation
The components of the sanitation system for this alternative would be identical to those shown in alternative B-E.

Alternative G-B – Desalination of seawater, additional water from the Colorado River and indirect potable reuse; and construction of a wastewater treatment plant in the Río Alamar area

Potable water
In this alternative, we propose to make up the projected potable water deficit for the year 2023 through the construction of a desalination plant, the construction of a new aqueduct from the Colorado River and the implementation of an indirect potable reuse program. Under this plan the desalination plant will have a maximum capacity of 690 L/s, while the piping and purification infrastructure of river water will provide up to 1,760 L/s and the reuse will provide up to 750 L/s.

The El Florido and Abelardo L. Rodríguez water treatment plants will continue operating, after renovation, to treat water coming from the Colorado River with a capacity of 4,500 L/s. (See Figure 12-9)

Table 12-18 shows the various projects that make up this alternative.

Table 12-18
Potable Water Projects for Alternative G-B

Project	Source of water	Maximum Capacity (L/s)	Average operational flow (L/s)
Base Infrastructure:			
El Florido Water Treatment Plant	Colorado River	4,000	4,000
Abelardo L. Rodríguez Water Treatment Plant	Colorado River	500	500
Río Alamar/Río Tijuana aquifer wells	Tijuana/Alamar aquifers	180	180
Monte de los Olivos Water Treatment plant	Tijuana/Alamar aquifer	250	250
La Misión wells	La Misión aquifer	51	51
Proposed Infrastructure:			
Desalination Plant	Pacific Ocean	690	400
Aqueduct and water treatment plant for water from the Colorado River	Colorado River	5,456	4,080
Microfiltration/reverse osmosis at La Morita and Monte de los Olivos (1) WWTPs	Effluent from the La Morita and Monte de los Olivos WWTPs	588	383
Microfiltration / reverse osmosis at Alamar Regional (1) WWTP	Effluent from the Alamar Regional WWTP	420	210
New wells (Extraction of the aquifer recharge)	Alamar aquifer	300	150
Water treatment plant for reuse flows from the Rodríguez reservoir	Effluent from the La Morita and Monte de los Olivos WWTPs	475	307
Total Supply		11,902	
Average daily demand			8,206
Maximum daily demand		11,902	

1) Not all the effluent treated through microfiltration and reverse osmosis is recovered for reuse due to the estimated efficiency of the process. The quantity of water that can be used corresponds to the new extraction wells (300 l/s) and to the treatment plant for reuse flows (475 l/s).

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Figure 12-9
Alternative G-B

As previously mentioned, the desalination plant is built to satisfy the maximum daily demand for water, however to estimate the operation and maintenance costs an operational flow equal to an average daily flow is used. On the other hand, the reuse infrastructure is built solely for the average daily flow, and it is assumed that the peaks in demand are satisfied by other sources.

The Colorado River aqueduct will be approximately 115 km long with a diameter of 102 cm. As part of this alternative, CESPT will have to acquire additional rights to the river water, probably through the purchase of those rights.

Table 12-19 shows the necessary infrastructure for the transport of the effluent for the indirect potable reuse system.

Table 12-19
Infrastructure for the Pipelines of Effluent for Indirect Potable Reuse Under Alternative G-B

Treatment Plant	Pumping (hp)	Conveyance Lines	
		Longitude (m)	Diameter (cm)
From Monte de los Olivos to La Morita WWTP [(1)]	1,900	6,500	76
From La Morita WWTP to the upstream recharge site of the Abelardo L. Rodríguez Reservoir	1,144	9,200	61
From Alamar Regional WWTP to the site for aquifer recharge	1,206	2,200	61

[1] The secondary effluent from La Morita for reuse will be sent to Monte de los Olivos, where the microfiltration/reverse osmosis process will take place for the secondary effluent of both plants.

Injection wells from the Río Alamar aquifer with a capacity of 420 L/s and a series of extraction wells of 300 L/s will be constructed. The number and placement of the wells will be determined through a specific study of the aquifer characteristics.

In addition to the purification plants and the projects for the production and reuse of water, this alternative includes the construction of a seawater main to the new desalinization plant 1,950 meters in length with a diameter of 76 cm; the construction of 13 master tanks with capacities from 500 to 20,000 m^3; 143,300 meters of water mains with diameters from 30 cm to 152 cm; 10 pumping plants with capacities from 100 to 2,200 hp; the construction of 270,000 meters of supply pipelines with diameters from 10 to 46 cm to increase service coverage of potable water to 100 percent of the population; the construction of 1,420,100 meters of supply pipelines from the primary network to service the areas of future growth; and the renovation of 247,600 meters of supply pipelines that are in poor condition.

Sanitation:

The components of the sanitation system for this alternative will be identical to those shown in alternative B-B.

Alternative G-C – Desalination of seawater, additional water from the Colorado River and indirect potable reuse; and construction of wastewater treatment plants in the Río Alamar and coastal areas

Potable water

The components of the water system for this alternative are identical to those in the previous alternative (G-B). (See Figure 12-10).

Sanitation

The components of the sanitation system for this alternative are identical to those shown in Alternative B-C.

Figure 12-10
Alternative G-C

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Alternative G-D – Desalination of seawater, additional water from the Colorado River and indirect potable reuse; and construction of a wastewater treatment plant in the coastal area

Potable water

With this Alternative, we propose to meet the potable water deficit projected for the year 2023 through the construction of a desalination plant with a capacity of 990 l/s, the construction of a new aqueduct from the Colorado River and the implementation of a program for indirect potable reuse. However, the indirect potable reuse will take place only with the effluent from the La Morita and Monte de los Olivos wastewater treatment plants, since there are no other plants in the basin of the Río Tijuana. The effluent from the treatment plant in the coastal area will be discharged into the ocean.

The El Florido and Abelardo L. Rodríguez water treatment plants will continue operating, after renovation, to treat water coming from the Colorado River with a capacity of 4,500 L/s. (See Figure 12-11).

Table 12-20 shows the different projects included in this Alternative.

Table 12-20
Potable Water Projects for Alternative G-D

Projects	Source of water	Maximum Capacity (L/s)	Average operational flow (L/s)
Base Infrastructure:			
El Florido Water Treatment Plant	Colorado River	4,000	4,000
Abelardo L. Rodríguez Water Treatment Plant	Colorado River	500	500
Río Alamar/Río Tijuana aquifer wells	Tijuana/Alamar aquifer	180	180
Monte de los Olivos Water Treatment Plant	Tijuana/Alamar aquifer	250	250
La Misión wells	La Misión aquifer	51	51
Proposed Infrastructure:			
Desalination Plant	Pacific Ocean	990	550
Aqueduct and treatment plant for water from the Colorado River	Colorado River	5,456	4,080
Microfiltration/reverse osmosis at La Morita and Monte de los Olivos (1) WWTPs	Effluent from the La Morita and Monte de los Olivos WWTPs	588	383
Water Treatment Plant for the reuse flows from the Rodríguez reservoir	Effluent from the La Morita and Monte de los Olivos WWTPs	475	307
Total Supply		11,902	
Average daily demand			8,206
Maximum daily demand		11,902	

1) These are parts of the proposed infrastructure required for water production. This water will later be purified. These quantities of water are not included as potable water for distribution or in the total amount.

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Figure 12-11
Alternative G-D

Table 12-21 shows the necessary infrastructure for the transport of the effluent for the indirect potable reuse system.

Table 12-21
Infrastructure for the Pipelines of Effluent for Indirect Potable Reuse Under Alternative G-D

Treatment Plant	Pumping (hp)	Conveyance Lines	
		Longitude (m)	Diameter (cm)
From Monte de los Olivos to La Morita WWTP (1)	1,900	6,500	76
From La Morita WWTP to the upstream recharge site of the Abelardo L. Rodríguez Reservoir	1,144	9,200	61

[1] The secondary effluent from La Morita for reuse will be sent to Monte de los Olivos, where the microfiltration/reverse osmosis process will take place for the secondary effluent of both plants.

In addition to the purification plants and the water production and reuse projects, this alternative includes the construction of a seawater main to the new desalination plant with a length of 1,950 meters and a diameter of 102 cm; the construction of 13 master tanks with capacities ranging from 500 to 20,000 m^3; 124,400 meters of water mains with diameters from 30 to 152 cm, 11 pumping plants with capacities from 50 to 3,500 hp-; the construction of 270,000 meters of supply pipelines with diameters from 10 to 46 cm to increase the service coverage of potable water to 100 percent of the population; the construction of 1,420,200 meters of supply pipelines from the primary network to service the areas of future growth; and the renovation of 247,600 meters of supply pipelines that are in poor condition.

Sanitation
The components of the sanitation system for this alternative are identical to those shown as part of alternative B-D.

Alternative G-E – Desalination of seawater, additional water from the Colorado River and indirect potable reuse; and construction of a wastewater treatment plant in the Río Alamar area and the expansion of the La Morita WWTP

Potable water
In this alternative we propose to face the deficit of potable water projected for the year 2023 through the construction of a desalination plant, the construction of a new aqueduct from the Colorado River and the implementation of an indirect potable reuse program. Under this plan, the desalination plant will have a maximum capacity of 413 l/s, while the infrastructure of transport and purification of water from the river will provide up to 1,760 l/s and the reuse up to 1,051 l/s. (See Figure 12-12)

The El Florido and Abelardo L. Rodríguez Water Treatment Plants will continue operating, after renovation, to treat water coming from the Colorado River with a capacity of 4,500 L/s.

Table 12-22 shows the various projects that make up this Alternative.

Table 12-22
Potable Water Projects for Alternative G-E

Project	Source of Water	Maximum Capacity (L/s)	Average Operational Flow (L/s)
Base Infrastructure:			
El Florido Water Treatment Plant	Colorado River	4,000	4,000
Abelardo L. Rodríguez Water Treatment Plant	Colorado River	500	500
Río Alamar/Río Tijuana aquifer wells	Tijuana/Alamar aquifer	180	180
Monte de los Olivos Water Treatment Plant	Tijuana/Alamar aquifer	250	250
La Misión wells	La Misión aquifer	51	51
Proposed Infrastructure:			
Desalination Plant	Pacific Ocean	413	180
Aqueduct and Water Treatment Plant for water from the Colorado River	Colorado River	5,456	4,080
Microfiltration/reverse osmosis at La Morita and Monte de los Olivos WWTPs	Effluent from La Morita and Monte de los Olivos WWTPs	931	659
Microfiltration/reverse osmosis at Alamar Regional WWTP	Effluent from Alamar Regional WWTP	420	210
New wells (Extraction of the aquifer recharge)	Alamar aquifer	300	150
Water Treatment Plant for reuse flows from the Rodríguez reservoir	Effluent from La Morita and Monte de los Olivos WWTPs	751	527
Total Supply		**11,902**	
Average daily demand			8,206
Maximum daily Demand		11,902	

(1) Not all the effluent treated through microfiltration and reverse osmosis is recovered for reuse due to the estimated efficiency of the process. The quantity of water that can be used corresponds to the new extraction wells (300 l/s) and to the treatment plant for reuse flows (475 l/s).

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Figure 12-12
Alternative G-E

As previously mentioned, the desalination plant is built to satisfy maximum daily demand of water, although to estimate operating and maintenance costs an operational flow equal to an average day is used. On the other hand, the reuse infrastructure is built only for the flow of an average day. It is assumed that the peaks in demand will be satisfied by other sources.

The Colorado River aqueduct will be approximately 115 km long with a diameter of 102 cm. As part of this alternative CESPT will have to acquire additional rights to the river water. It is estimated that this will have to be done through the purchase of the rights.

Table 12-23 shows the necessary infrastructure for the transport of effluent for the indirect potable reuse system.

Table 12-23
Infrastructure for the Pipelines of Effluent for Indirect Potable Reuse Under Alternative G-E

Treatment Plant	Pumping (hp)	Conveyance Lines	
		Longitude (m)	Diameter (cm)
From Monte de los Olivos to La Morita WWTP [(1)]	1,900	6,500	76
From La Morita WWTP to the upstream recharge site of the Abelardo L. Rodríguez Reservoir	1,144	9,200	61
From Alamar Regional WWTP to the site for aquifer recharge	1,206	2,200	61

[1] The secondary effluent from La Morita for reuse will be sent to Monte de los Olivos, where the microfiltration/reverse osmosis process will take place for the secondary effluent of both plants.

Injection wells from the aquifer of the Río Alamar with a capacity of 420 L/s and a series of extraction wells of 300 L/s will be constructed. The number and placement of the wells will be determined through a specific study of the aquifer characteristics.

In addition to the water treatment plants and the water production and reuse projects, this alternative includes the construction of a seawater main to the new desalination plant with a length of 1,950 meters and a diameter of 61 cm; the construction of 13 master tanks with capacities from 500 to 20,000 m3; 89,700 meters of water mains with diameters from 30 to 152 cm; 10 pumping plants with capacities from 100 to 7,600 hp; the construction of 270,000 meters of supply pipelines with diameters from 10 to 46 cm to increase service coverage of potable water to 100 percent of the population; the construction of 1,420,200 meters of supply pipelines from the primary network to service the area of future growth; and the renovation of 247,600 meters of supply pipelines that are in poor condition.

Sanitation
The components of the sanitation system for this alternative will be identical to those shown as part of Alternative B-E.

12.2 Evaluation Criteria

In addition to the typical technical tasks involved in developing an infrastructure plan, an integral planning strategy includes identifying and weighting objectives. Section 4 describes the results of workshops on sustainable development in which we determined the objectives and indicators of sustainability to be used in the master plan:

- Protect public health
- Provision of low cost services
- Reduce environmental impact
- Foster a water-conscious mindset
- Minimization of operational risks
- Reduce discharge of wastewater into transborder waters
- Diversify sources of supply
- Minimization of risks associated with operational waste materials
- Maximization of reuse of wastewater
- Conserve water and reduce leaks
- Insure sustainable management of aquifers

Once these objectives were established, we developed criteria and indicators necessary to be able to quantify how each alternative meets the objectives. Table 12-24 shows the criteria and indicators for each objective in the master plan.

Table 12-24
Objectives, Criterion and Indicators for the Evaluation of Alternatives

Infrastructure Category	Master Plan Objectives	Criteria (Key Indicator) for the Evaluation of Alternatives	Components
All	Count on water and sewage services available to the population [1]	Cost of the alternative	Annual present value based on capital cost and operating and maintenance costs
All	Reduce environmental impact	Level of environmental impact	1 Impact on quality of receiving waters 2 Impact of discomfort (noise, offensive odors) 3 Impact on endangered species and their habitats 4 Impact of construction
All	Protect human health	Implementation of adequate improvements to the water and sewage system to protect human health	1 Coverage in 2008.Same for all alternatives 2 Coverage in 2013.Same for all alternatives 3 Coverage in 2023.Same for all alternatives
All	Develop a water-conscious mindset	Number of water education programs	1 Number of water conservation programs. Same for all alternatives 2 Number of water service payment programs. Same for all alternatives 3 Number of programs for appropriate use of drainage. Same for all alternatives. 4 Percentage of population that receives educational material. Same for all alternatives
All	The selected alternative should have an acceptable level of implementation and operational risks	Level of implementation and operational risk (high, medium, or low) [2]	1 Political risk, public acceptance and equity factors 2 Risk based on uncertainty of land use projects
Water Supply	Maintain flexible supply sources	Percentage of contribution from the major supply source	Percentage contributed by major water source
Water Supply	Conserve water and reduce leaks	Percentage of conserved water and reduction of water loss	1 Percentage of reduction in water loss. Same for all alternatives 2 Percentage of conservation on commercial and government buildings Same for alternatives
Water Supply	Sustain groundwater extraction	Proportion of extracted groundwater to artificial aquifer recharge with adequate water quality	Proportion of extracted groundwater to artificial aquifer recharge with adequate water quality
Wastewater Collection System	Reduce discharge of wastewater into transborder waters	Reduction of the volume of water discharged into transborder waters	Quantity and location of discharge into transborder waters
Wastewater reuse and treatment	Eliminate health and environmental risks associated with sludge	Efficient sludge handling	Index of impacts from operational waste materials
Wastewater reuse and treatment	Maximize reuse of wastewater	Percentage of reused effluent volume	Percentage of reused effluent volume

Though all the established objectives for the master plan are important to CESPT, not all of the objectives are of equal importance, therefore the indicators were weighted, as described in Section 4. Table 12-25 shows the results of the weighting process.

Table 12-25
Criteria for Evaluation of Alternatives

	Weight
Cost of the alternative	19%
Percentage of contribution from major supply source	18%
Level of environmental impact	14%
Level of implementation and operational risk (high, medium, or low)	13%
Percentage of reused effluent volume	13%
Reduce volume of water discharged into transborder waters	9%
Proportion of extracted groundwater to artificial aquifer recharge with adequate water quality	9%
Efficient sludge handling	6%

Note: Only criteria that were expected to differ among alternatives were weighted. Other criteria are weighted equally for all the alternatives.

The way that these criteria and their weighting are used in the prioritization of alternatives is described in Section 12.4.

As observed in the previous table, one of the most important criteria according to CESPT is the cost of the alternatives. The next section describes the cost estimates of the proposed infrastructure for the alternatives in the master plan. The remaining criteria and the comparison of alternatives according to each criterion will be described in Section 12.4.

12.3 Cost Estimates

Estimates of annual operating and maintenance costs were made for each of the twelve alternatives. In addition, based on these two figures, total costs annualized to present value were calculated for a more direct comparison between the total costs of each Alternative.

Investment costs were estimated from equations showing the relationship between the capacity of different projects and their investment costs. The equations were developed using as much information from similar projects throughout Mexico as it was possible to obtain. Sources included cost curves for hydraulic projects and catalogs of unit prices published in 2001 by the National Water Commission (CNA). The data published by the CNA were brought up to date in September 2002 with inflation information provided by the Bank of Mexico.

However, for some types of projects, such as desalination plants or infrastructure for advanced wastewater treatment for indirect potable reuse, there is not enough historical data in Mexico. For that reason, data was obtained from similar projects in the United States. These types of projects are quite sophisticated and require imported construction materials and equipment, so the construction costs are assumed to be similar to those seen in the United States.

Annual operating and maintenance costs were estimated based on electricity requirements, chemical reagents, and labor required for each project. Unit prices used for these three components correspond to current prices seen in Tijuana and in some cases to prices paid by CESPT to its suppliers.

The estimated annualized cost of investment was obtained using an interest rate of 12 percent, which was approved by the Binational Technical Committee, and the discount rate for the present value was also at 12 percent.

A factor of 25 percent was applied for unforeseen costs of investment, and a factor of 20 percent of the subtotal for engineering and administrative costs of the project. These factors were not applied to operating and maintenance costs.

The methodology used for cost estimates is presented in more detail in Appendix R. It contains equations used for each type of project, along with investment costs and operating and maintenance costs.

Tables 12-26 through 12-37 present the detailed costs of each alternative broken down by project. Appendix R presents the information in these tables in more detail.

Table 12-26
Cost Summary for Alternative B-B

Wastewater	Investment Cost (Dlls	Operating and Maintenance Cost (Dlls)	Total Annualized Cost (Dlls)
Existing WWTPs			
Rosarito I Upgrade	1,191,519	147,594	307,113
Proposed WWTPs			
Alamar Regional	28,688,965	2,252,480	6,093,323
Rosarito I Expansion and Enlargement	2,361,965	197,055	513,272
Popotla	3,490,265	293,243	760,515
Mesa del Descanso	1,421,715	109,327	299,665
Puerto Nuevo	1,421,715	109,327	299,665
La Misión	1,233,665	88,477	253,638
Subtotal	**38,618,288**	**3,049,909**	**8,220,078**
Proposed wastewater mains	25,104,185	2,421,749	5,782,667
Proposed effluent mains	34,787,013	695,740	5,352,983
Primary Sewer Lines	52,799,517	1,055,990	8,124,725
Sewage Recollection System (secondary) to cover 100% of the current service	41,679,804	833,596	6,413,637
Sewage Recollection System (secondary) to cover future growth	71,711,206	1,434,224	11,034,833

Table 12-26
Cost Summary for Alternative B-B

Wastewater	Investment Cost (Dlls	Operating and Maintenance Cost (Dlls)	Total Annualized Cost (Dlls)
Upgrade and substitution of Sewage pipelines currently in a bad state	22,063,106	441,262	3,395,044
Potable Water			
Existing Infrastructure			
El Florido Treatment Plant	3,125,301	770,779	1,189,191
Abelardo L. Rodríguez Treatment Plant	518,873	963,685	1,033,151
Proposed production Infrastructure			
Desalination Plant	286,438,207	31,038,545	69,386,543
Potable water mains	91,003,715	18,106,484	30,289,951
Potable Water Distribution System (secondary) to cover 100% of the current service	4,819,308	96,386	741,589
Potable Water Distribution System (secondary) to cover future growth	55,786,885	1,115,738	8,584,418
Upgrade and substitution of pipelines currently in a bad state	11,131,378	222,628	1,712,883
Subtotal (Dlls)	**740,778,304**	**62,394,310**	**161,568,806**
% of unforeseen	25%		
Unforeseen (Dlls)	185,194,576		
Sub-total (Dlls)	925,972,879		
% Administration and Engineering	20%		
Administration and Engineering (Dlls)	185,194,576		
Total (Dlls)	**1,111,167,455**	**62,394,310**	**211,156,054**

Note: The factors of unforeseen and administrative and engineering costs are applied only to the sum of the investment costs, so the estimates presented broken down by project must be adjusted with these factors before they are used.

Table 12-27
Cost Summary for Alternative B-C

Wastewater	Investment Cost (Dlls)	Operating and Maintenance Cost (Dlls)	Total Annualized Cost (Dlls)
Existing WWTPs			
Rosarito I Upgrade	1,191,519	147,594	307,113
Proposed WWTPs			
Regional Alamar	21,543,065	1,706,246	4,590,405
Regional Coastal Watershed	8,191,515	671,838	1,768,508
Rosarito I Expansion and Enlargement	2,361,965	197,055	513,272
Popotla	3,490,265	293,243	760,515
Mesa del Descanso	1,421,715	109,327	299,665
Puerto Nuevo	1,421,715	109,327	299,665
La Misión	1,233,665	88,477	253,638
Subtotal	**39,663,902**	**3,175,512**	**8,485,667**
Proposed wastewater mains	28,886,424	2,946,297	6,813,576
Proposed effluent mains	34,787,013	695,740	5,352,983

Table 12-27
Cost Summary for Alternative B-C

Wastewater	Investment Cost (Dlls)	Operating and Maintenance Cost (Dlls)	Total Annualized Cost (Dlls)
Primary Sewer Lines	52,822,997	1,056,460	8,128,338
Sewage Recollection System (secondary) to cover 100% of the current service	41,679,804	833,596	6,413,637
Sewage Recollection System (secondary) to cover future growth	71,711,206	1,434,224	11,034,833
Upgrade and substitution of Sewage pipelines currently in a bad state	22,063,106	441,262	3,395,044
Potable Water			
Existing Infrastructure			
El Florido Treatment Plant	3,125,301	770,779	1,189,191
Abelardo L. Rodríguez Treatment Plant	518,873	963,685	1,033,151
Proposed production Infrastructure			
Desalination Plant	286,438,207	31,038,545	69,386,543
Potable water mains	91,003,715	18,106,484	30,289,951
Potable Water Distribution System (secondary) to cover 100% of the current service	4,819,308	96,386	741,589
Potable Water Distribution System (secondary) to cover future growth	55,786,885	1,115,738	8,584,418
Upgrade and substitution of pipelines currently in a bad state	11,131,378	222,628	1,712,883
Subtotal (Dlls)	**745,629,638**	**63,044,931**	**162,868,918**
% of unforeseen	25%		
Unforeseen (Dlls)	186,407,409		
Sub-total (Dlls)	932,037,047		
% Administration and Engineering	20%		
Administration and Engineering (Dlls)	186,407,409		
Total (Dlls)	**1,118,444,457**	**63,044,931**	**212,780,911**

Note: The factors of unforeseen and administrative and engineering costs are applied only to the sum of the investment costs, so the estimates presented broken down by project must be adjusted with these factors before they are used.

Table 12-28
Cost Summary for Alternative B-D

Wastewater	Investment Cost (Dlls)	Operating and Maintenance Cost (Dlls)	Total Annualized Cost (Dlls)
Existing WWTPs			
Rosarito I Upgrade	1,191,519	147,594	307,113
Proposed WWTPs			
Regional Coastal Watershed	28,688,965	2,252,480	6,093,323
Rosarito I Expansion and Enlargement	2,361,965	197,055	513,272
Popotla	3,490,265	293,243	760,515
Mesa del Descanso	1,421,715	109,327	299,665
Puerto Nuevo	1,421,715	109,327	299,665

Table 12-28 Cost Summary for Alternative B-D			
Wastewater	**Investment Cost (Dlls)**	**Operating and Maintenance Cost (Dlls)**	**Total Annualized Cost (Dlls)**
La Misión	1,233,665	88,477	253,638
Subtotal	**38,618,288**	**3,049,909**	**8,220,078**
Proposed wastewater conveyance lines	63,625,944	1,392,944	9,911,107
Proposed effluent conveyance lines	15,897,370	317,947	2,446,268
Primary sanitary sewage conveyance lines	53,272,577	1,065,452	8,197,519
Sewage Recollection System (secondary) to cover 100% of the current service	41,679,804	833,596	6,413,637
Sewage Recollection System (secondary) to cover future growth	71,711,206	1,434,224	11,034,833
Upgrade and substitution of Sewage pipelines currently in a bad state	22,063,106	441,262	3,395,044
Potable Water			
Existing Infrastructure			
El Florido Treatment Plant	3,125,301	770,779	1,189,191
Abelardo L. Rodríguez Treatment Plant	518,873	963,685	1,033,151
Proposed production Infrastructure			
Desalination Plant	286,438,207	31,038,545	69,386,543
Potable water mains	91,003,715	18,106,484	30,289,951
Potable Water Distribution System (secondary) to cover 100% of the current service	4,819,308	96,386	741,589
Potable Water Distribution System (secondary) to cover future growth	55,786,885	1,115,738	8,584,418
Upgrade and substitution of pipelines currently in a bad state	11,131,378	222,628	1,712,883
Subtotal (Dlls)	**760,883,481**	**60,997,173**	**162,863,325**
% of unforeseen	25%		
Unforeseen (Dlls)	190,220,870		
Sub-total (Dlls)	951,104,351		
% Administration and Engineering	20%		
Administration and Engineering (Dlls)	190,220,870		
Total (Dlls)	**1,141,325,222**	**60,997,173**	**213,796,401**

Note: The factors of unforeseen and administrative and engineering costs are applied only to the sum of the investment costs, so the estimates presented broken down by project must be adjusted with these factors before they are used.

Table 12-29
Cost Summary for Alternative B-E

Wastewater	Investment Cost (Dlls)	Operating and Maintenance Cost (Dlls)	Total Annualized Cost (Dlls)
Existing WWTPs			
Rosarito I Upgrade	1,191,519	147,594	307,113
Proposed WWTPs			
Regional Alamar	19,474,515	1,547,500	4,154,724
La Morita Expansion	10,260,065	834,322	2,207,927
Rosarito I Expansion and Enlargement	2,361,965	197,055	513,272
Popotla	3,490,265	293,243	760,515
Mesa del Descanso	1,421,715	109,327	299,665
Puerto Nuevo	1,421,715	109,327	299,665
La Misión	1,233,665	88,477	253,638
Subtotal	**39,663,902**	**3,179,252**	**8,489,406**
Proposed wastewater conveyance lines	23,551,377	2,111,774	5,264,803
Proposed effluent conveyance lines	34,787,013	695,740	5,352,983
Primary sanitary sewage conveyance lines	50,601,395	1,012,028	7,786,481
Sewage Recollection System (secondary) to cover 100% of the current service	41,679,804	833,596	6,413,637
Sewage Recollection System (secondary) to cover future growth	71,711,206	1,434,224	11,034,833
Upgrade and substitution of Sewage pipelines currently in a bad state	22,063,106	441,262	3,395,044
Potable Water			
Existing Infrastructure			
El Florido Treatment Plant	3,125,301	770,779	1,189,191
Abelardo L. Rodríguez Treatment Plant	518,873	963,685	1,033,151
Proposed production Infrastructure			
Desalination Plant	286,438,207	31,038,545	69,386,543
Potable water mains	91,003,715	18,106,484	30,289,951
Potable Water Distribution System (secondary) to cover 100% of the current service	4,819,308	96,386	741,589
Potable Water Distribution System (secondary) to cover future growth	55,786,885	1,115,738	8,584,418
Upgrade and substitution of pipelines currently in a bad state	11,131,378	222,628	1,712,883
Subtotal (Dlls)	**738,072,989**	**62,169,715**	**160,982,027**
% of unforeseen	25%		
Unforeseen (Dlls)	184,518,247		
Sub-total (Dlls)	922,591,236		
% Administration and Engineering	20%		
Administration and Engineering (Dlls)	184,518,247		
Total (Dlls)	**1,107,109,483**	**62,169,715**	**210,388,182**

Note: The factors of unforeseen and administrative and engineering costs are applied only to the sum of the investment costs, so the estimates presented broken down by project must be adjusted with these factors before they are used.

Table 12-30
Cost Summary for Alternative F-B

Wastewater	Investment Cost (Dlls)	Operating and Maintenance Cost (Dlls)	Total Annualized Cost (Dlls)
Existing WWTPs			
Rosarito I Upgrade	1,191,519	147,594	307,113
Proposed WWTPs			
Regional Alamar	28,688,965	2,252,480	6,093,323
Rosarito I Expansion and Enlargement	2,361,965	197,055	513,272
Popotla	3,490,265	293,243	760,515
Mesa del Descanso	1,421,715	109,327	299,665
Puerto Nuevo	1,421,715	109,327	299,665
La Misión	1,233,665	88,477	253,638
Subtotal	**38,618,288**	**3,049,909**	**8,220,078**
Proposed wastewater conveyance lines	25,104,185	2,421,749	5,782,667
Proposed effluent conveyance lines	34,787,013	695,740	5,352,983
Primary sanitary sewage conveyance lines	52,799,517	1,055,990	8,124,725
Sewage Recollection System (secondary) to cover 100% of the current service	41,679,804	833,596	6,413,637
Sewage Recollection System (secondary) to cover future growth	71,711,206	1,434,224	11,034,833
Upgrade and substitution of Sewage pipelines currently in a bad state	22,063,106	441,262	3,395,044
Potable Water			
Existing Infrastructure			
El Florido Treatment Plant	3,125,301	770,779	1,189,191
Abelardo L. Rodríguez Treatment Plant	518,873	963,685	1,033,151
Proposed production Infrastructure			
Desalination Plant	220,615,231	21,015,090	50,550,788
Indirect potable reuse			
Alamar WWTP membranes/reverse osmosis	32,587,102	2,677,381	7,040,102
La Morita and Monte de los Olivos WWTPs membranes/reverse osmosis	44,473,087	3,833,794	9,787,796
New WTP Rodríguez additional flows	15,760,288	949,501	3,059,469
Potable water mains	133,533,608	21,462,562	39,339,879
Potable Water Distribution System (secondary) to cover 100% of the current service	4,819,308	96,386	741,589
Potable Water Distribution System (secondary) to cover future growth	55,786,885	1,115,738	8,584,418
Upgrade and substitution of pipelines currently in a bad state	11,131,378	222,628	1,712,883
Subtotal (Dlls)	**810,305,697**	**63,187,608**	**171,670,346**
% of unforeseen	25%		
Unforeseen (Dlls)	202,576,424		
Sub-total (Dlls)	1,012,882,121		
% Administration and Engineering	20%		
Administration and Engineering (Dlls)	202,576,424		
Total (Dlls)	**1,215,458,546**	**63,187,608**	**225,911,715**

Note: The factors of unforeseen and administrative and engineering costs are applied only to the sum of the investment costs, so the estimates presented broken down by project must be adjusted with these factors before they are used.

Table 12-31
Cost Summary for Alternative F-C

Wastewater	Investment Cost (Dlls)	Operating and Maintenance Cost (Dlls)	Total Annualized Cost (Dlls)
Existing WWTPs			
Rosarito I Upgrade	1,191,519	147,594	307,113
Proposed WWTPs			
Regional Alamar	21,543,065	1,706,246	4,590,405
Regional Coastal Watershed	8,191,515	671,838	1,768,508
Rosarito I Expansion and Enlargement	2,361,965	197,055	513,272
Popotla	3,490,265	293,243	760,515
Mesa del Descanso	1,421,715	109,327	299,665
Puerto Nuevo	1,421,715	109,327	299,665
La Misión	1,233,665	88,477	253,638
Subtotal	**39,663,902**	**3,175,512**	**8,485,667**
Proposed wastewater conveyance lines	28,886,424	2,946,297	6,813,576
Proposed effluent conveyance lines	34,787,013	695,740	5,352,983
Primary sanitary sewage conveyance lines	52,822,997	1,056,460	8,128,338
Sewage Recollection System (secondary) to cover 100% of the current service	41,679,804	833,596	6,413,637
Sewage Recollection System (secondary) to cover future growth	71,711,206	1,434,224	11,034,833
Upgrade and substitution of Sewage pipelines currently in a bad state	22,063,106	441,262	3,395,044
Potable Water			
Existing Infrastructure			
El Florido Treatment Plant	3,125,301	770,779	1,189,191
Abelardo L. Rodríguez Treatment Plant	518,873	963,685	1,033,151
Proposed production Infrastructure			
Desalination Plant	220,615,231	21,015,090	50,550,788
Indirect potable reuse			
Alamar WWTP membranes/reverse osmosis	32,587,102	2,677,381	7,040,102
La Morita and Monte de los Olivos WWTPs membranes/reverse osmosis	44,473,087	3,833,794	9,787,796
Treatment of water product from the aquifer injection	-	-	-
New WTP Rodríguez additional flows	15,760,288	949,501	3,059,469
Potable water mains	133,533,608	21,462,562	39,339,879
Potable Water Distribution System (secondary) to cover 100% of the current service	4,819,308	96,386	741,589
Potable Water Distribution System (secondary) to cover future growth	55,786,885	1,115,738	8,584,418
Upgrade and substitution of pipelines currently in a bad state	11,131,378	222,628	1,712,883
Subtotal (Dlls)	**815,157,032**	**63,838,229**	**172,970,457**
% of unforeseen	25%		
Unforeseen (Dlls)	203,789,258		
Sub-total (Dlls)	1,018,946,289		
% Administration and Engineering	20%		
Administration and Engineering (Dlls)	203,789,258		
Total (Dlls)	**1,222,735,547**	**63,838,229**	**227,536,572**

Note: The factors of unforeseen and administrative and engineering costs are applied only to the sum of the investment costs, so the estimates presented broken down by project must be adjusted with these factors before they are used.

Table 12-32
Cost Summary for Alternative F-D

Wastewater	Investment Cost (Dlls)	Operating and Maintenance Cost (Dlls)	Total Annualized Cost (Dlls)
Existing WWTPs			
Rosarito I Upgrade	1,191,519	147,594	307,113
Proposed WWTPs			
Regional Coastal Watershed	28,688,965	2,252,480	6,093,323
Rosarito I Expansion and Enlargement	2,361,965	197,055	513,272
Popotla	3,490,265	293,243	760,515
Mesa del Descanso	1,421,715	109,327	299,665
Puerto Nuevo	1,421,715	109,327	299,665
La Misión	1,233,665	88,477	253,638
Subtotal	**38,618,288**	**3,049,909**	**8,220,078**
Proposed wastewater conveyance lines	63,625,944	1,392,944	9,911,107
Proposed effluent conveyance lines	15,897,370	317,947	2,446,268
Primary sanitary sewage conveyance lines	53,272,577	1,065,452	8,197,519
Sewage Recollection System (secondary) to cover 100% of the current service	41,679,804	833,596	6,413,637
Sewage Recollection System (secondary) to cover future growth	71,711,206	1,434,224	11,034,833
Upgrade and substitution of Sewage pipelines currently in a bad state	22,063,106	441,262	3,395,044
Potable Water			
Existing Infrastructure			
El Florido Treatment Plant	3,125,301	770,779	1,189,191
Abelardo L. Rodríguez Treatment Plant	518,873	963,685	1,033,151
Proposed production Infrastructure			
Desalination Plant	246,203,245	25,076,445	58,037,835
Indirect potable reuse			
La Morita and Monte de los Olivos WWTPs membranes/reverse osmosis	44,473,087	3,833,794	9,787,796
New WTP Rodríguez additional flows	15,760,288	949,501	3,059,469
Potable water mains	113,319,789	19,482,261	34,653,376
Potable Water Distribution System (secondary) to cover 100% of the current service	4,819,308	96,386	741,589
Potable Water Distribution System (secondary) to cover future growth	55,786,885	1,115,738	8,584,418
Upgrade and substitution of pipelines currently in a bad state	11,131,378	222,628	1,712,883
Subtotal (Dlls)	**803,197,968**	**61,194,144**	**168,725,308**
% of unforeseen	25%		
Unforeseen (Dlls)	200,799,492		
Sub-total (Dlls)	1,003,997,460		
% Administration and Engineering	20%		
Administration and Engineering (Dlls)	200,799,492		
Total (Dlls)	**1,204,796,951**	**61,194,144**	**222,490,890**

Note: The factors of unforeseen and administrative and engineering costs are applied only to the sum of the investment costs, so the estimates presented broken down by project must be adjusted with these factors before they are used.

Table 12-33
Cost Summary for Alternative F-E

Wastewater	Investment Cost (Dlls)	Operating and Maintenance Cost (Dlls)	Total Annualized Cost (Dlls)
Existing WWTPs			
Rosarito I Upgrade	1,191,519	147,594	307,113
Proposed WWTPs			
Regional Alamar	19,474,515	1,547,500	4,154,724
La Morita Expansion	10,260,065	834,322	2,207,927
Rosarito I Expansion and Enlargement	2,361,965	197,055	513,272
Popotla	3,490,265	293,243	760,515
Mesa del Descanso	1,421,715	109,327	299,665
Puerto Nuevo	1,421,715	109,327	299,665
La Misión	1,233,665	88,477	253,638
Subtotal	**39,663,902**	**3,179,252**	**8,489,406**
Proposed wastewater conveyance lines	23,551,377	2,111,774	5,264,803
Proposed effluent conveyance lines	34,787,013	695,740	5,352,983
Primary sanitary sewage conveyance lines	50,601,395	1,012,028	7,786,481
Sewage Recollection System (secondary) to cover 100% of the current service	41,679,804	833,596	6,413,637
Sewage Recollection System (secondary) to cover future growth	71,711,206	1,434,224	11,034,833
Upgrade and substitution of Sewage pipelines currently in a bad state	22,063,106	441,262	3,395,044
Potable Water			
Existing Infrastructure			
El Florido Treatment Plant	3,125,301	770,779	1,189,191
Abelardo L. Rodríguez Treatment Plant	518,873	963,685	1,033,151
Proposed production Infrastructure			
Desalination Plant	196,591,375	16,989,988	43,309,401
Indirect potable reuse			
Alamar WWTP membranes/reverse osmosis	45,311,260	3,917,333	9,983,549
La Morita and Monte de los Olivos WWTPs membranes/reverse osmosis	68,005,188	2,076,632	11,181,084
New WTP Rodríguez additional flows	23,369,961	1,106,095	4,234,837
Potable water mains	138,307,866	20,959,581	39,476,069
Potable Water Distribution System (secondary) to cover 100% of the current service	4,819,308	96,386	741,589
Potable Water Distribution System (secondary) to cover future growth	55,786,885	1,115,738	8,584,418
Upgrade and substitution of pipelines currently in a bad state	11,131,378	222,628	1,712,883
Subtotal (Dlls)	**832,216,715**	**58,074,315**	**169,490,473**
% of unforeseen	25%		
Unforeseen (Dlls)	208,054,179		
Sub-total (Dlls)	1,040,270,894		
% Administration and Engineering	20%		
Administration and Engineering (Dlls)	208,054,179		
Total (Dlls)	**1,248,325,073**	**58,074,315**	**225,198,552**

Note: The factors of unforeseen and administrative and engineering costs are applied only to the sum of the investment costs, so the estimates presented broken down by project must be adjusted with these factors before they are used.

Table 12-34 Cost Summary for Alternative G-B			
Wastewater	**Investment Cost (Dlls)**	**Operating and Maintenance Cost (Dlls)**	**Total Annualized Cost (Dlls)**
Existing WWTPs			
Rosarito I Upgrade	1,191,519	147,594	307,113
Proposed WWTPs			
Regional Alamar	28,688,965	2,252,480	6,093,323
Rosarito I Expansion and Enlargement	2,361,965	197,055	513,272
Popotla	3,490,265	293,243	760,515
Mesa del Descanso	1,421,715	109,327	299,665
Puerto Nuevo	1,421,715	109,327	299,665
La Misión	1,233,665	88,477	253,638
Subtotal	**38,618,288**	**3,049,909**	**8,220,078**
Proposed wastewater conveyance lines	25,104,185	2,421,749	5,782,667
Proposed effluent conveyance lines	34,771,385	695,428	5,350,578
Primary sanitary sewage conveyance lines	52,799,517	1,055,990	8,124,725
Sewage Recollection System (secondary) to cover 100% of the current service	41,679,804	833,596	6,413,637
Sewage Recollection System (secondary) to cover future growth	71,711,206	1,434,224	11,034,833
Upgrade and substitution of Sewage pipelines currently in a bad state	22,063,106	441,262	3,395,044
Potable Water			
Existing Infrastructure			
El Florido Treatment Plant	3,125,301	770,779	1,189,191
Abelardo L. Rodríguez Treatment Plant	518,873	963,685	1,033,151
Proposed production Infrastructure			
Desalination Plant	66,196,397	10,244,871	19,107,163
New Aqueduct Colorado River up to the Panda Reservoir site (40 in.)	117,824,960	10,186,128	24,478,723
Purchase of rights of Colorado River water from Agricultural community	8,325,504		1,114,608
New WTP from water from the new aqueduct (Valle Dorado neighborhood)	48,612,564	1,247,370	7,755,561
New line from Panda Reservoir to Valle Dorado neighborhood WTP	7,884,081	157,682	1,213,193
Indirect potable reuse			
Alamar WWTP membranes/reverse osmosis	32,587,102	1,277,942	5,640,663
La Morita and Monte de los Olivos WWTPs membranes/reverse osmosis	44,473,087	2,426,477	8,380,480
Treatment of water product from the aquifer injection	-	-	-
New WTP Rodríguez additional flows	15,760,288	854,183	2,964,151
Potable water mains	139,067,867	13,918,771	32,537,007
Potable Water Distribution System (secondary) to cover 100% of the current service	4,819,308	96,386	741,589
Potable Water Distribution System (secondary) to cover future growth	55,786,885	1,115,738	8,584,418
Upgrade and substitution of pipelines currently in a bad state	11,131,378	222,628	1,712,883
Subtotal (Dlls)	**844,052,603**	**53,562,391**	**165,081,457**
% of unforeseen	25%		
Unforeseen (Dlls)	211,013,151		
Sub-total (Dlls)	1,055,065,753		

Table 12-34
Cost Summary for Alternative G-B

Wastewater	Investment Cost (Dlls)	Operating and Maintenance Cost (Dlls)	Total Annualized Cost (Dlls)
% Administration and Engineering	20%		
Administration and Engineering (Dlls)	211,013,151		
Total (Dlls)	**1,266,078,904**	**53,562,391**	**220,840,990**

Note: The factors of unforeseen and administrative and engineering costs are applied only to the sum of the investment costs, so the estimates presented broken down by project must be adjusted with these factors before they are used.

Table 12-35
Cost Summary for Alternative G-C

Wastewater	Investment Cost (Dlls)	Operating and Maintenance Cost (Dlls)	Total Annualized Cost (Dlls)
Existing WWTPs			
Rosarito I Upgrade	1,191,519	147,594	307,113
Proposed WWTPs			
Regional Alamar	21,543,065	1,706,246	4,590,405
Regional Coastal Watershed	8,191,515	671,838	1,768,508
Rosarito I Expansion and Enlargement	2,361,965	197,055	513,272
Popotla	3,490,265	293,243	760,515
Mesa del Descanso	1,421,715	109,327	299,665
Puerto Nuevo	1,421,715	109,327	299,665
La Misión	1,233,665	88,477	253,638
Subtotal	**39,663,902**	**3,175,512**	**8,485,667**
Proposed wastewater conveyance lines	28,886,424	2,946,297	6,813,576
Proposed effluent conveyance lines	34,787,013	695,740	5,352,983
Primary sanitary sewage conveyance lines	52,822,997	1,056,460	8,128,338
Sewage Recollection System (secondary) to cover 100% of the current service	41,679,804	833,596	6,413,637
Sewage Recollection System (secondary) to cover future growth	71,711,206	1,434,224	11,034,833
Upgrade and substitution of Sewage pipelines currently in a bad state	22,063,106	441,262	3,395,044
Potable Water			
Existing Infrastructure			
El Florido Treatment Plant	3,125,301	770,779	1,189,191
Abelardo L. Rodríguez Treatment Plant	518,873	963,685	1,033,151
Proposed production Infrastructure			
Desalination Plant	66,196,397	10,244,871	19,107,163
New Aqueduct Colorado River up to the Panda Reservoir site (40 in.)	117,824,960	10,186,128	24,478,723
Purchase of rights of Colorado River water from Agricultural community	8,325,504		1,114,608
New WTP from water from the new aqueduct (Valle Dorado neighborhood)	48,612,564	1,247,370	7,755,561
New line from the Binational aqueduct to Valle Dorado neighborhood WTP	7,884,081	157,682	1,213,193
Indirect potable reuse			
Alamar WWTP membranes/reverse osmosis	32,587,102	1,277,942	5,640,663

Table 12-35 Cost Summary for Alternative G-C			
Wastewater	**Investment Cost (Dlls)**	**Operating and Maintenance Cost (Dlls)**	**Total Annualized Cost (Dlls)**
La Morita and Monte de los Olivos WWTPs membranes/reverse osmosis	44,473,087	2,426,477	8,380,480
Treatment of water product from the aquifer injection	-	-	-
New WTP Rodríguez additional flows	15,760,288	854,183	2,964,151
Proposed infrastructure of capturing conveyance lines	139,067,867	12,428,362	31,046,599
Potable Water Distribution System (secondary) to cover 100% of the current service	4,819,308	96,386	741,589
Potable Water Distribution System (secondary) to cover future growth	55,786,885	1,115,738	8,584,418
Upgrade and substitution of pipelines currently in a bad state	11,131,378	222,628	1,712,883
Subtotal (Dlls)	**848,919,565**	**52,722,916**	**164,893,565**
% of unforeseen	25%		
Unforeseen (Dlls)	212,229,891		
Sub-total (Dlls)	1,061,149,456		
% Administration and Engineering	20%		
Administration and Engineering (Dlls)	212,229,891		
Total (Dlls)	**1,273,379,347**	**52,722,916**	**220,978,889**
Note: The factors of unforeseen and administrative and engineering costs are applied only to the sum of the investment costs, so the estimates presented broken down by project must be adjusted with these factors before they are used.			

Table 12-36 Cost Summary for Alternative G-D			
Wastewater	**Investment Cost (Dlls)**	**Operating and Maintenance Cost (Dlls)**	**Total Annualized Cost (Dlls)**
Existing WWTPs			
Rosarito I Upgrade	1,191,519	147,594	307,113
Proposed WWTPs			
Regional Coastal Watershed	28,688,965	2,252,480	6,093,323
Rosarito I Expansion and Enlargement	2,361,965	197,055	513,272
Popotla	3,490,265	293,243	760,515
Mesa del Descanso	1,421,715	109,327	299,665
Puerto Nuevo	1,421,715	109,327	299,665
La Misión	1,233,665	88,477	253,638
Subtotal	**38,618,288**	**3,049,909**	**8,220,078**
Proposed wastewater conveyance lines	63,625,944	1,392,944	9,911,107
Proposed effluent conveyance lines	15,897,370	317,947	2,446,268
Primary sanitary sewage conveyance lines	53,272,577	1,065,452	8,197,519
Sewage Recollection System (secondary) to cover 100% of the current service	41,679,804	833,596	6,413,637
Sewage Recollection System (secondary) to cover future growth	71,711,206	1,434,224	11,034,833
Upgrade and substitution of Sewage pipelines currently in a bad state	22,063,106	441,262	3,395,044
Potable Water			

Table 12-36 Cost Summary for Alternative G-D			
Wastewater	**Investment Cost (Dlls)**	**Operating and Maintenance Cost (Dlls)**	**Total Annualized Cost (Dlls)**
Existing Infrastructure			
El Florido Treatment Plant	3,125,301	770,779	1,189,191
Abelardo L. Rodríguez Treatment Plant	518,873	963,685	1,033,151
Proposed production Infrastructure			
Desalination Plant	93,278,413	12,893,209	25,381,209
New Aqueduct Colorado River up to the Panda Reservoir site (40 in.)	117,824,960	10,186,128	24,478,723
Purchase of rights of Colorado River water from Agricultural community	8,325,504		1,114,608
New WTP from water from the new aqueduct (Valle Dorado neighborhood)	48,612,564	1,247,370	7,755,561
New line from the Binational aqueduct to Valle Dorado neighborhood WTP	7,884,081	157,682	1,213,193
Indirect potable reuse			
La Morita and Monte de los Olivos WWTPs membranes/reverse osmosis	44,473,087	2,426,477	8,380,480
New WTP Rodríguez additional flows	15,760,288	854,183	2,964,151
Potable water mains	124,001,314	12,222,573	28,823,717
Potable Water Distribution System (secondary) to cover 100% of the current service	4,819,308	96,386	741,589
Potable Water Distribution System (secondary) to cover future growth	55,786,885	1,115,738	8,584,418
Upgrade and substitution of pipelines currently in a bad state	11,131,378	222,628	1,712,883
Subtotal (Dlls)	**843,601,770**	**51,839,765**	**163,298,474**
% of unforeseen	25%		
Unforeseen (Dlls)	210,900,442		
Sub-total (Dlls)	1,054,502,212		
% Administration and Engineering	20%		
Administration and Engineering (Dlls)	210,900,442		
Total (Dlls)	**1,265,402,655**	**51,839,765**	**219,027,828**
Note: The factors of unforeseen and administrative and engineering costs are applied only to the sum of the investment costs, so the estimates presented broken down by project must be adjusted with these factors before they are used.			

Table 12-37 Cost Summary for Alternative G-E			
Wastewater	**Investment Cost (Dlls)**	**Operating and Maintenance Cost (Dlls)**	**Total Annualized Cost (Dlls)**
Existing WWTPs			
Rosarito I Upgrade	1,191,519	147,594	307,113
Proposed WWTPs			
Regional Alamar	19,474,515	1,547,500	4,154,724
La Morita Expansion	10,260,065	834,322	2,207,927
Rosarito I Expansion and Enlargement	2,361,965	197,055	513,272
Popotla	3,490,265	293,243	760,515
Mesa del Descanso	1,421,715	109,327	299,665
Puerto Nuevo	1,421,715	109,327	299,665
La Misión	1,233,665	88,477	253,638
Subtotal	**39,663,902**	**3,179,252**	**8,489,406**
Proposed wastewater conveyance lines	23,551,377	2,111,774	5,264,803
Proposed effluent conveyance lines	34,787,013	695,740	5,352,983
Primary sanitary sewage conveyance lines	50,601,395	1,012,028	7,786,481
Sewage Recollection System (secondary) to cover 100% of the current service	41,679,804	833,596	6,413,637
Sewage Recollection System (secondary) to cover future growth	71,711,206	1,434,224	11,034,833
Upgrade and substitution of Sewage pipelines currently in a bad state	22,063,106	441,262	3,395,044
Potable Water			
Existing Infrastructure			
El Florido Treatment Plant	3,125,301	770,779	1,189,191
Abelardo L. Rodríguez Treatment Plant	518,873	963,685	1,033,151
Proposed production Infrastructure			
Desalination Plant	40,651,845	5,756,068	11,198,487
New Aqueduct Colorado River up to the Panda Reservoir site (40 in.)	117,824,960	10,186,128	24,478,723
Purchase of rights of Colorado River water from Agricultural community	8,325,504		1,114,608
New WTP from water from the new aqueduct (Valle Dorado neighborhood)	48,612,564	1,247,370	7,755,561
New line from the Binational aqueduct to Valle Dorado neighborhood WTP	7,884,081	157,682	1,213,193
Indirect potable reuse			
Alamar WWTP membranes/reverse osmosis	32,587,102	1,277,942	5,640,663
La Morita and Monte de los Olivos WWTPs membranes/reverse osmosis	68,005,188	4,329,661	13,434,112
Treatment of water product from the aquifer injection	-	-	-
New WTP Rodríguez additional flows	23,369,961	979,004	4,107,746
Potable water mains	142,028,352	14,484,850	33,499,432
Potable Water Distribution System (secondary) to cover 100% of the current service	4,819,308	96,386	741,589
Potable Water Distribution System (secondary) to cover future growth	55,786,885	1,115,738	8,584,418
Upgrade and substitution of pipelines currently in a bad state	11,131,378	222,628	1,712,883
Subtotal (Dlls)	**849,920,624**	**51,443,390**	**163,748,059**
% of unforeseen	25%		
Unforeseen (Dlls)	212,480,156		

Table 12-37 Cost Summary for Alternative G-E			
Wastewater	**Investment Cost (Dlls)**	**Operating and Maintenance Cost (Dlls)**	**Total Annualized Cost (Dlls)**
Sub-total (Dlls)	1,062,400,780		
% Administration and Engineering	20%		
Administration and Engineering (Dlls)	212,480,156		
Total (Dlls)	**1,274,880,935**	**51,443,390**	**219,900,394**
Note: The factors of unforeseen and administrative and engineering costs are applied only to the sum of the investment costs, so the estimates presented broken down by project must be adjusted with these factors before they are used.			

Table 12-38 summarizes the investment cost estimates for each alternative broken down by potable water projects and sewage and sanitation projects.

Table 12-38 Summary of the Capital Investment Costs Estimates of the Alternatives (Millions of Dollars)			
Alternative	**Wastewater**	**Potable Water**	**Total**
BB	432	679	1,111
BC	439	679	1,118
BD	462	679	1,141
BE	428	679	1,107
FB	432	784	1,215
FC	439	784	1,223
FD	462	743	1,205
FE	428	820	1,248
GB	432	834	1,266
GC	439	834	1,273
GD	462	803	1,265
GE	428	847	1,275

As the information indicates, the alternatives whose only source of water is a new desalination plant have the lowest investment cost, followed by alternatives that combine the three water sources (desalination, Colorado River, indirect potable reuse). The most expensive alternatives are those that depend mostly on reuse, which means that this is the most expensive source in terms of investment cost.

As the information indicates, the alternatives whose only source of water is a new desalination plant have the lowest investment cost, followed by alternatives that combine the three water sources (desalination, Colorado River, indirect potable reuse). The most expensive alternatives are those that depend mostly on reuse, which means that this is the most expensive source in terms of investment cost. The main reasons for this are the need to convey the secondary effluent to the membrane plants, the required investments for the membrane processes, the need for effluent conveyance infrastructure for the membranes upstream the Abelardo L. Rodríguez reservoir, and the need to construct a new conventional treatment plant to treat new flows (reuse flows) originating from the Abelardo L. Rodríguez reservoir.

The least expensive sanitation alternatives are those projects with two treatment plants in the Tijuana River Basin, i.e., the Alamar Regional Plant and the expansion of the La Morita Plant (B-E, F-E, and G-E). This is due mainly to less need for infrastructure of wastewater conveyance. The most expensive alternatives are those that have one or two treatment plants in the coastal zone, whose conveyance and pumping requirements are higher.

Table 12-39 summarizes estimated annual operating and maintenance costs for each alternative broken down by potable water projects and sewage and sanitation projects.

Table 12-39
Summary of Annual Operation and Maintenance Cost Estimates of the Alternatives (Millions of Dollars)

Alternative	Wastewater	Potable Water	Total
BB	10	52	62
BC	11	52	63
BD	9	52	61
BE	10	52	62
FB	10	53	63
FC	11	53	64
FD	9	53	61
FE	10	48	58
GB	10	43	54
GC	11	42	53
GD	9	43	52
GE	10	42	51

As this table indicates, the least expensive operating and maintenance costs for potable water projects are those alternatives that combine three sources of water (Colorado River, desalination, and indirect potable reuse). The most expensive are those that depend most on desalination.

The least expensive sewage and sanitation alternatives are those with a treatment plant in the coastal area. This is mainly because the water is moved by gravity to the coastal area through a tunnel. Similarly, alternatives that include expansion of the La Morita plant (B-E, F-E, and G-E) would have lower operating costs than Alternatives B-B, F-B and G-B, given the transportation of water to this plant would require less pumping.

Finally, Table 12-40 indicates the annualized total cost for each alternative.

Table 12-40
Summary of Estimates of Total Annualized Costs of Each Alternative (Millions of Dollars)

Alternative	Wastewater	Potable Water	Total
BB	68	143	211
BC	70	143	213
BD	71	143	214
BE	67	143	210
FB	68	158	226
FC	70	158	228
FD	71	152	222
FE	67	158	225
GB	68	153	221
GC	70	151	221
GD	71	148	219
GE	67	153	220

As seen in the table, the annualized costs of the potable water system are much greater than the costs of the sanitation system. This is mainly due to the requirements of the large water production projects, such as the desalination plants, the additional transport of water from the Colorado River, and the infrastructure for indirect potable reuse.

The alternatives with the lowest annualized water costs are those that combine the three water sources, while the most expensive are those that only include the desalination alternative. Among the most economical sanitation alternatives is the expansion of La Morita, while the most expensive are those that call for plants along the coast, mainly due to the funding cost of the tunnel's investment.

The total annualized cost allows for a more direct comparison between alternatives keeping in mind the investment, operation, and maintenance costs throughout the planning period. It is important to note that although the cost of the alternatives is one of the most important selection criteria, other factors should be taken into account. These factors are described in the next section.

12.4 Alternative Evaluation and Recommendation

12.4.1 Summary of General Methodology

Decision making for the master plan followed a protocol in which alternatives were technically evaluated according to each of the plan criteria and indicators. For each Alternative, value was placed on the following criteria:

- Present Value
- Environmental Impact

- Percentage of Reused Effluent
- Recharge Extraction Ratio
- Risk and Reliability of Implementation
- Relative Contribution from Principal Source
- Quantity and Location of Discharge
- Disposed or Efficiently Reused Sludge

With this system an initial comparison between alternatives for each criterion can be done individually. This comparison is found in Section 12.4.2. However, prioritization of alternatives should be based on how well the alternatives collectively meet the plan objectives. To do this, the decision making in the plan was based on the Simple Multi-attribute Rate Technique.

Following this methodology, a uniform scale needs to be established for each criterion. As described in the following section, each criterion uses different units of measurement: dollars, percentages, indexes, m^3/s, etc. Therefore, a common scale must be established.

The master plan used a scale of 0.00 to 1.00 to normalize the results by alternative for each criterion. The following figure shows two examples of scales for two different criteria:

Value	Cost Measurement
1.00	30-40 Millions of Dollars
0.75	41-50 Millions of Dollars
0.50	51-60 Millions of Dollars
0.25	61-70 Millions of Dollars
0.00	70-80 Millions of Dollars

Value	Effluent Reuse Measurement
1.00	90%-100% Effluent reused
0.75	80%-89% Effluent reused
0.50	70%-79% Effluent reused
0.25	60%-69% Effluent reused
0.00	50%-59% Effluent reused

In this way criteria with differing scales, like those in the example (millions of dollars and percentage), are normalized to a scale with no units, a scale that is common to all the criteria.

Once an alternative is analyzed and a quantitative value for each criterion is determined (45 million dollars, 50 percent of reused effluent, etc), a score for each criterion is made on a scale of 0.00 to 1.00. This score is then multiplied by the weight of the criterion in question, to obtain a result signifying the contribution of the specific criterion to the total score of the alternative. The sum of the contributions by criteria then equals the total score of an alternative.

Figure 12-13 shows an example based on the two previous example criteria, and figure 12-14 gives a summary of the comparison process.

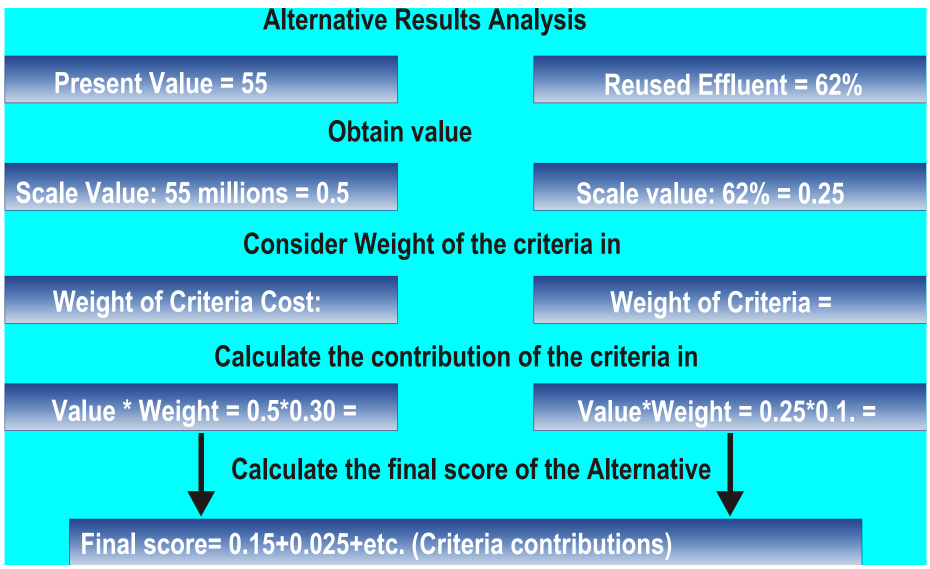


Figure 12-13
Process to Calculate the Alternatives Selection

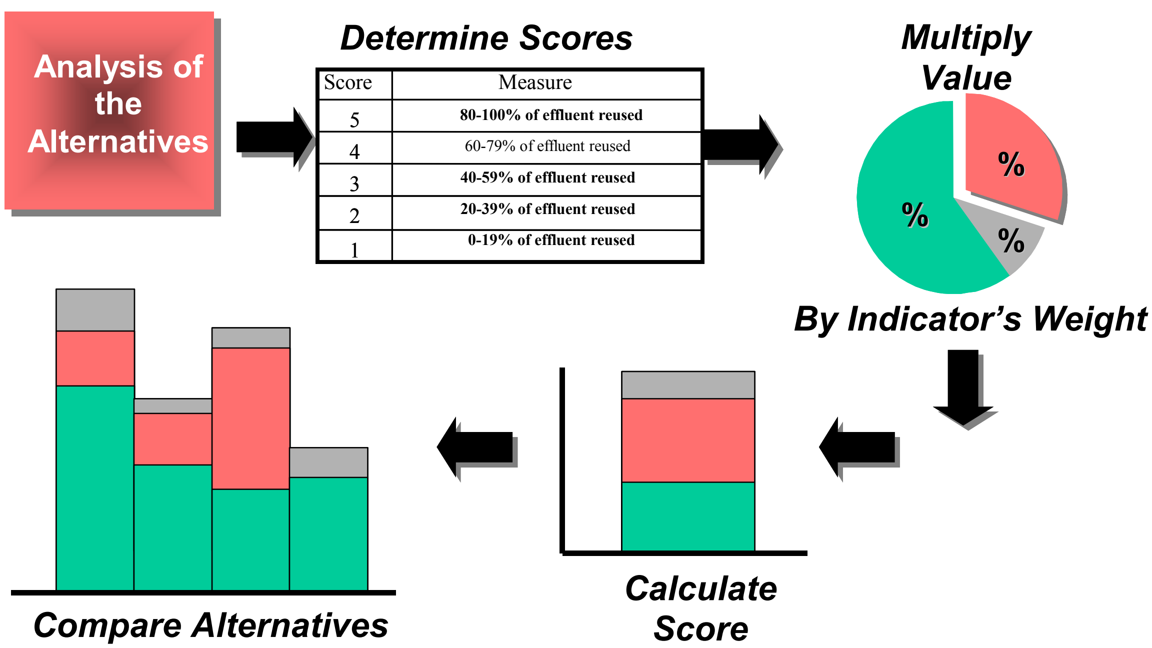


Figure 12-14
Summary of Comparison Process

12.4.2 Comparison of Alternatives by Criteria

As was previously mentioned, eight criteria (of the 11 that CESPT and the master plan Technical committee established as the most important) are used for the evaluation and selection of alternatives. These criteria are:

- Total annualized cost (which considers the investment and operation and maintenance costs)
- Level of environmental impact
- Level of implementation risk
- Percentage of total supply coming from the primary water source
- Proportion of extracted groundwater to artificial aquifer recharge
- Reduction of water volume discharged into transborder water courses
- Efficient sludge handling
- Percentage of effluent reused

Below we will present a comparison of the twelve alternatives for each one of the eight evaluation criteria.

Total Annualized Cost

The costs are expressed as a total annual cost (i.e. the annualized cost of investment plus the operation and maintenance costs). The annualized investment costs are calculated using a 12% discount rate during a 20-year amortization period. Figure 12-15 shows the comparison of the twelve alternatives in graph format.

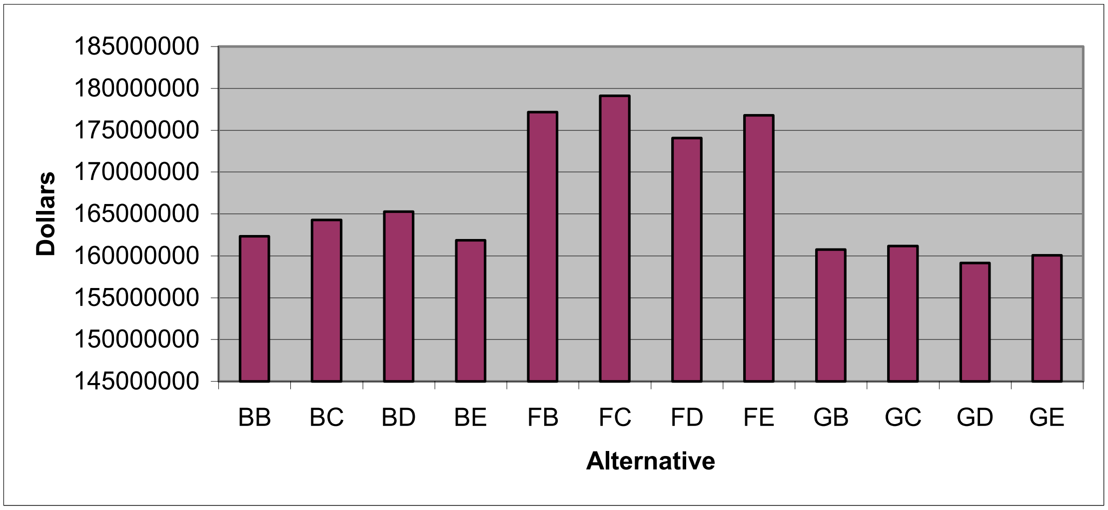


Figure 12-15
Comparison of Alternatives by Costs

As seen in this Figure, the alternatives that combine the three water sources (the Colorado River, desalination and indirect potable reuse (G-B, G-D and G-E) have the lowest annualized cost. On the other hand, the alternatives that include desalination and indirect potable reuse are the most expensive. It can be concluded that the indirect potable reuse option is the most expensive, followed by the desalination of seawater. The most economical option is the transport and purification of additional water supplies from the Colorado River.

As Section 12.3 demonstrates, the total cost of the alternatives is determined principally by the cost of the potable water projects, more so than by the sanitation projects.

Level of Environmental Impact

As indicated in Appendix S, the potential environmental impact of each alternative is estimated by considering the selected site (30%), the protection of conservation areas (25%), the protection of species of interest (25%), and the protection of streams and bodies of water (20%). Based on this, a scale was created with scores ranging from 1 to 5. The highest scores represent a lesser environmental impact. Figure 12-16 shows, in graph format, a comparison of the potential environmental impacts of each Alternative.

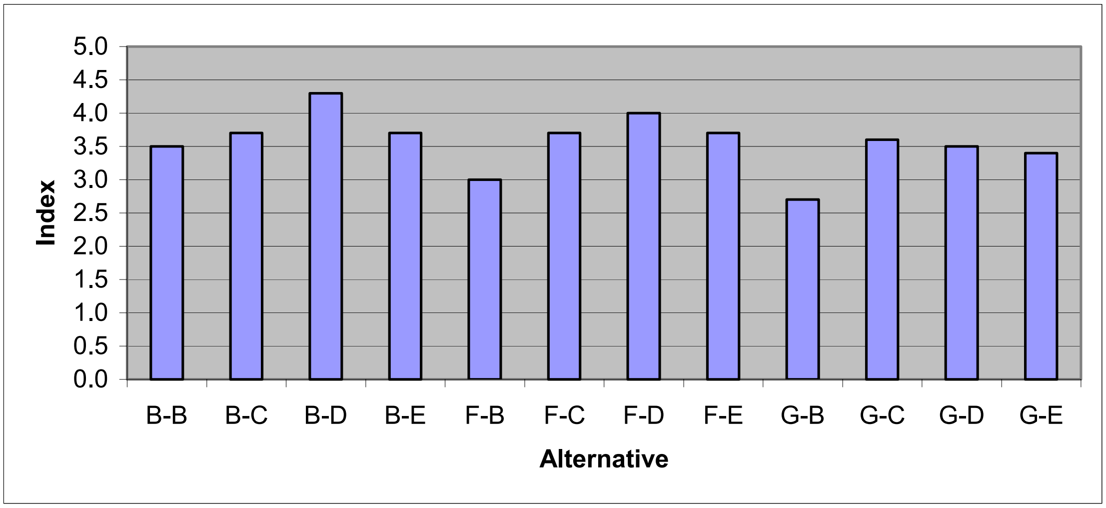


Figure 12-16
Comparison of Alternatives based on Environmental Impact

Level of implementation risk

The level of implementation risk was calculated based on the compilation of scores provided by different members of the teams from CESPT and CDM. The higher the score assigned to each alternative, the lower the implementation risk. The index considers the following:

- Political risk, public acceptance, and equity factors
- Risk based on uncertain land use projections

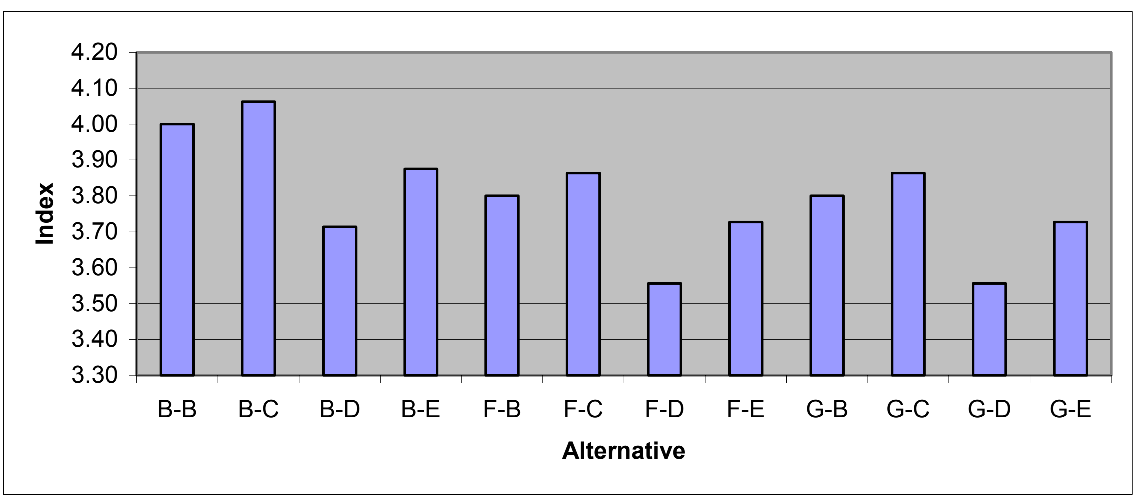


Figure 12-17
Comparison of Alternatives based on Risk

As shown in Figure 12-17, the alternatives that include indirect potable reuse show the greatest implementation risk, mainly due to the potential public acceptance risks.

Percentage of total supply coming from the primary water source

As mentioned, the Colorado River currently provides approximately 95% of the total water supply for Tijuana and Playas de Rosarito. Due to the considerable dependence on a single source, CESPT is interested in diversification. Therefore, this evaluation criterion for the alternatives was chosen.

The scores assigned to each alternative correspond to the percentage of the total supply provided by its main source, which is the Colorado River for all of the alternatives. For Alternatives B and F, the river will provide 66% of the total supply by the year 2023. For Alternative G, the river's contribution will be increased to 75% because of the construction of a new aqueduct. (See Figure 12-18)

Note that for this criterion in particular, a greater score corresponds to a less favorable Alternative, since it represents less diversity of sources.

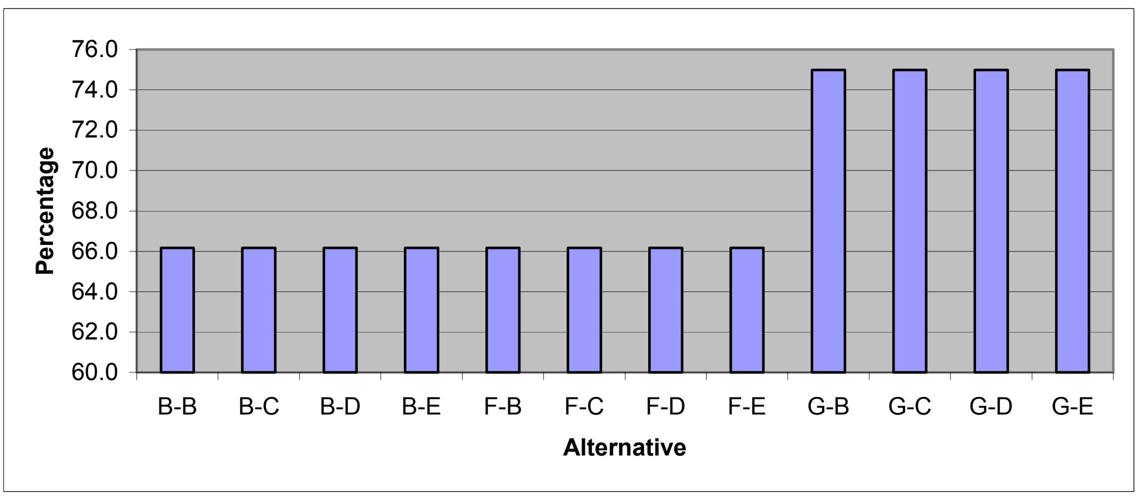


Figure 12-18
Comparison of Alternatives per Contribution of the Main Source

Percentage of extracted groundwater to artificial aquifer recharge

Similar to the previous one, this criterion measures the contribution of each alternative to the diversification of sources through the artificial recharge of aquifers with water of satisfactory quality. The value assigned to each alternative corresponds to the proportion of the artificial aquifer recharge to the amount of groundwater extracted. All the alternatives that include groundwater recharge have the same value of 38%. (See Figure 12-19)

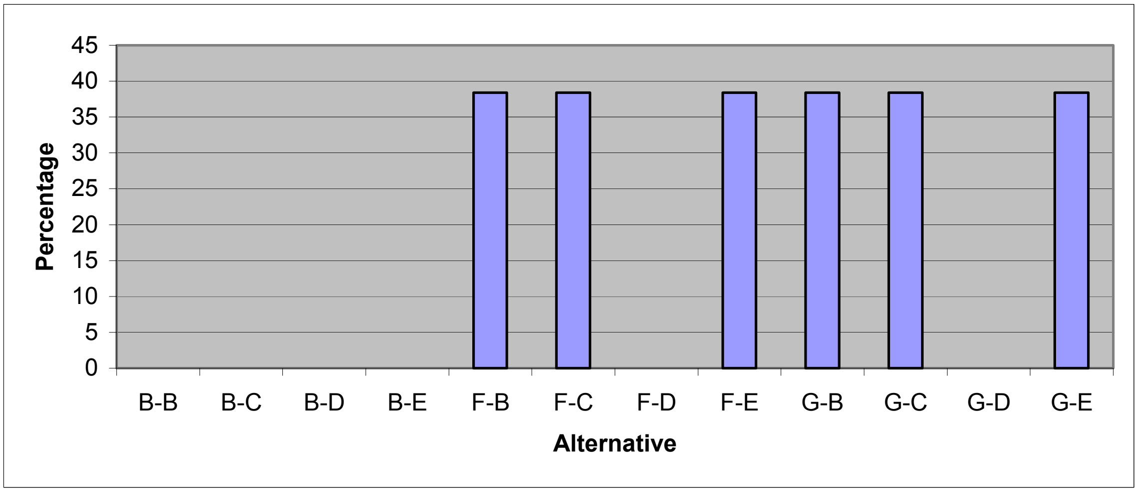


Figure 12-19
Comparison of Alternatives by Aquifer Recharge

Reduction of the volume of water discharged into transborder watercourses
The original objective of this criterion was to evaluate the alternatives in relation to the amount of treated wastewater that would be discharged into transborder watercourses, principally the Tijuana River. However, once the alternatives were developed, it was found that none of them would discharge into transborder bodies of water, except the Pacific Ocean. Therefore, the use of this criterion, in the way in which it was originally considered, turned out to be irrelevant.

With the goal of measuring the potential impacts of water discharge in the United States in some other way, it was assumed that the alternatives that discharged to the ocean outfall in San Diego showed a lesser risk to the environment or to human health in a transborder context. Under this criterion, the sanitation Alternatives B and E turned out to be the most favorable, since the principal treatment plants would be located within the Río Tijuana basin and would discharge everything into the ocean outfall. On the other hand, Alternatives C and D would place treatment plants in the coastal basin that would discharge directly into the sea. (See Figure 12-20)

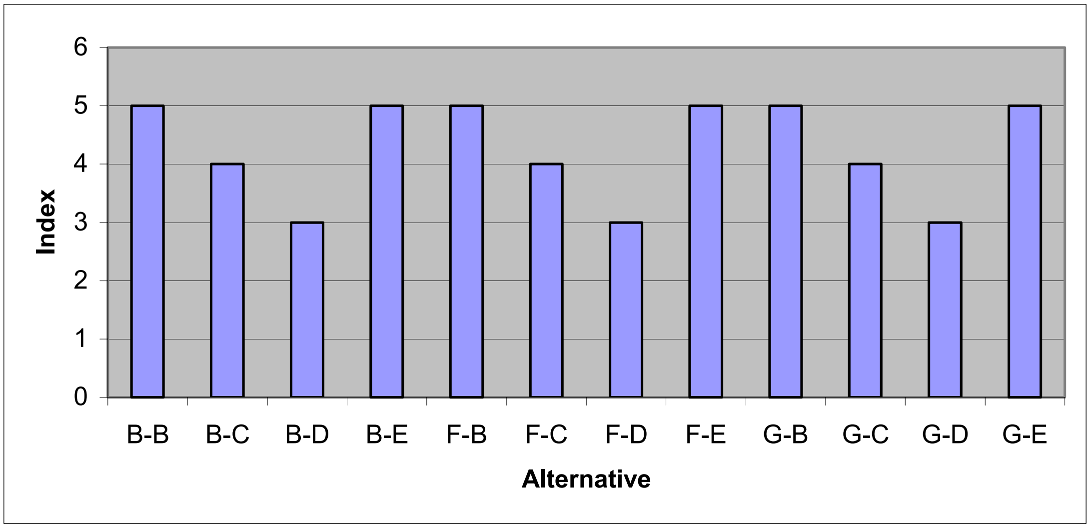


Figure 12-20
Comparison of Alternatives by Transboundary Water Discharge

Efficient sludge management
The proposed infrastructure for the alternatives includes, among other things, wastewater treatment plants, surface water purification plants, and desalination plants for seawater. During the operation of these plants, wastes are generated that should be handled and disposed of appropriately. Proper disposal will entail financial costs and a potential environmental impact, which should be considered during the evaluation of alternatives.

The wastewater treatment plants will generate biosolids. The quantity and quality of the biosolids produced will depend upon, among other things, the type of treatment and the volume treated. However, since all the alternatives will provide the same treatment capacity and use the same technology for planning purposes, this criterion will not be relevant to the sanitation system.

On the other hand, production of potable water will yield varying amounts of waste depending on the alternative chosen. The purification plants will generate sludge, while the desalination plants will generate brine. In order to minimize the amount of byproducts and their handling, the alternatives that do not include desalination are preferred because the need for brine treatment is eliminated. Thus, as indirect potable reuse and the use of the Colorado River water (Alternatives F and G) increase, higher scores will be obtained. (See Figure 12-21)

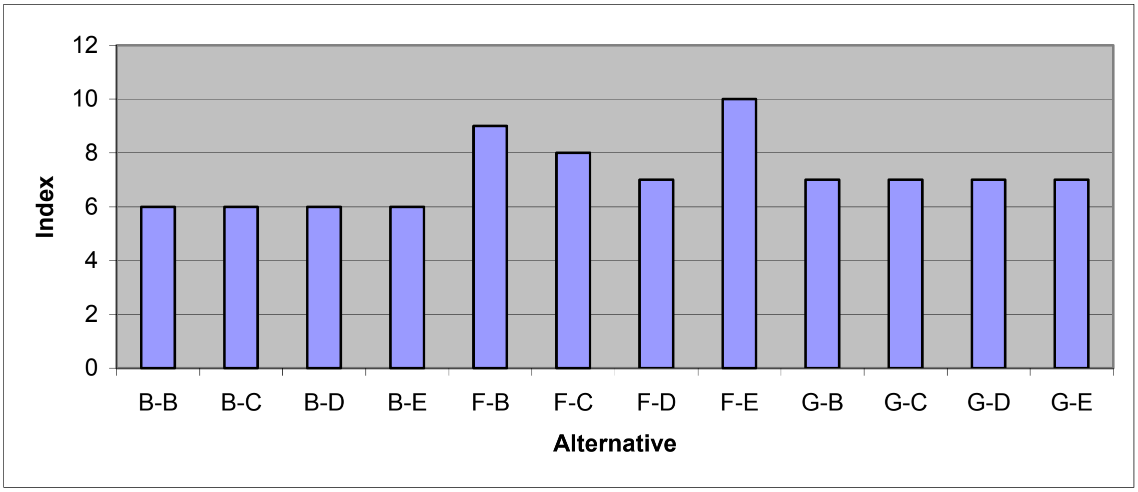


Figure 12-21
Comparison of Alternatives per Sludge Impact

Percentage of reused effluent

CESPT has an interest in promoting the reuse of wastewater with the goal of reducing dependence on new sources of water, promoting diversification of sources, and reducing the demand. Indirect potable reuse is considered a potential water source that is included in some alternatives, while non-potable reuse is considered a program that should be implemented by CESPT, independently of the chosen alternative.

The scores assigned to each alternative for this criterion correspond to the percentage of effluent produced that is reused through the discharge of water upstream of the Rodríguez reservoir or through recharge to the aquifer. The alternatives that include discharge to these two bodies of water receive a score of 14%, while the alternatives that only discharge to the reservoir (wastewater D) have a score of 8%. Alternatives F-E and G-E include additional reuse from the expansion of the La Morita WWTP, and have a score of 18%. (See Figure 12-22)

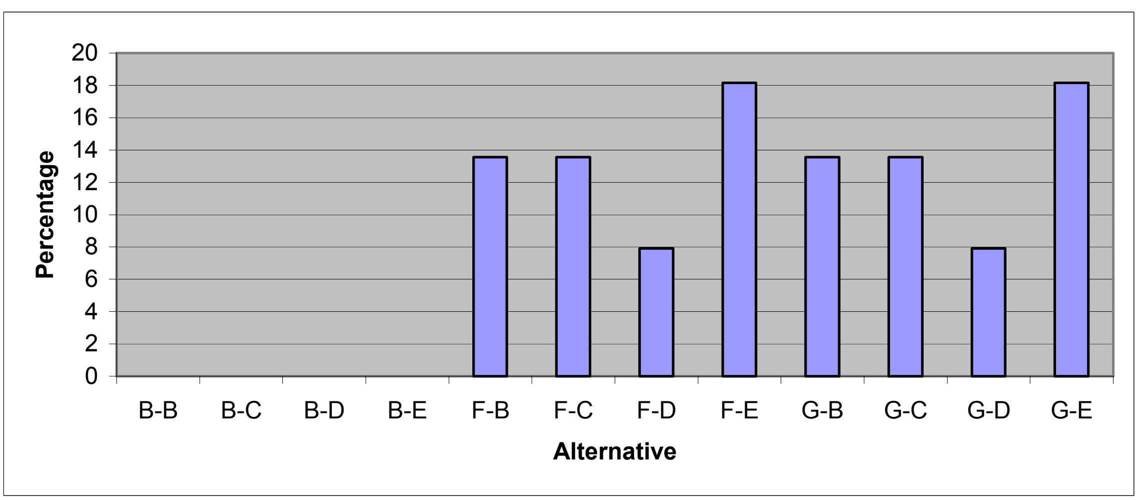


Figure 12-22
Comparison of Alternatives by Effluent Reuse

12.4.3 Evaluation of the Alternatives Considering all the Criteria

Following the methodology previously described, the scores assigned to each alternative were normalized to values between 0.00 and 1.00. The normalized score was weighted according to the criteria also described in the previous section. The sum of the weighted scores resulted in a total score for each alternative. Figure 12-23 shows the total scores for the alternatives, sorted from greater to lesser.

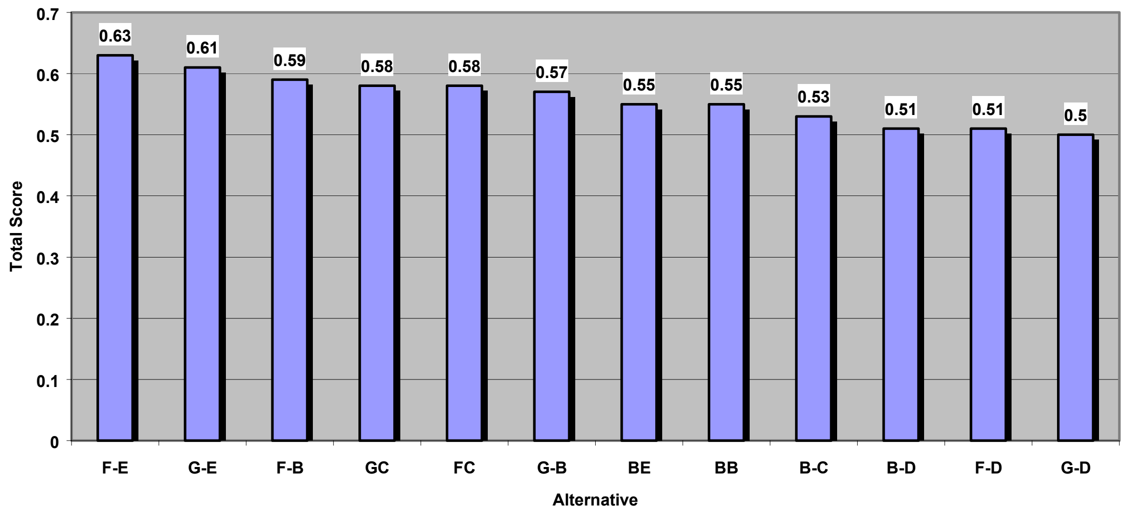
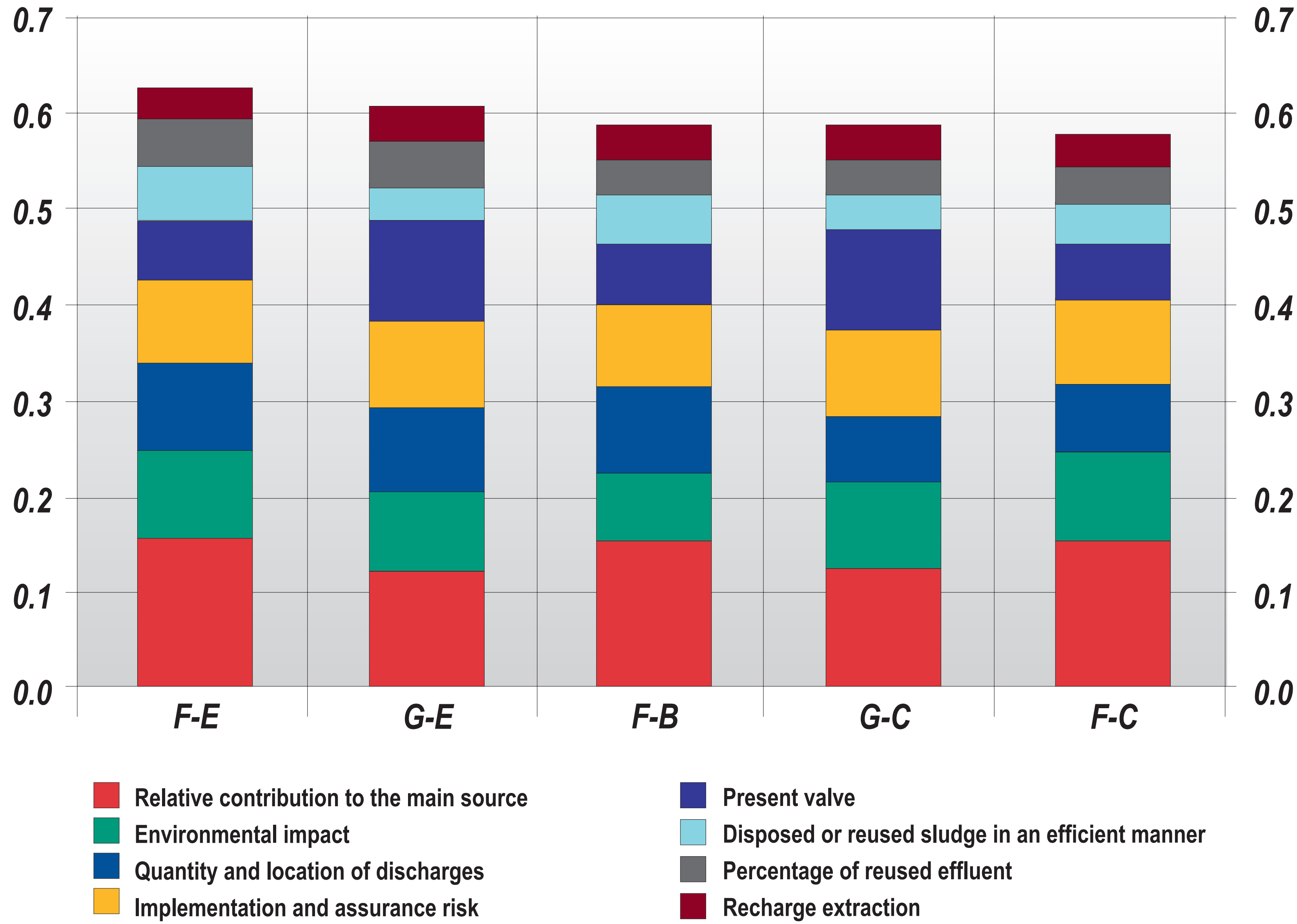


Figure 12-23
Comparison of Alternatives Based on All Criteria

As can be seen in the graph, the comparison of alternatives indicates that the Alternatives F-E, G-E and F-B most consistently achieve the objectives of the master plan. Alternative F-E received the highest score due to its contribution to each one of the objectives of the master plan. Alternatives G-E and F-B also had elements that made them stand out in the analysis of the combined criteria.

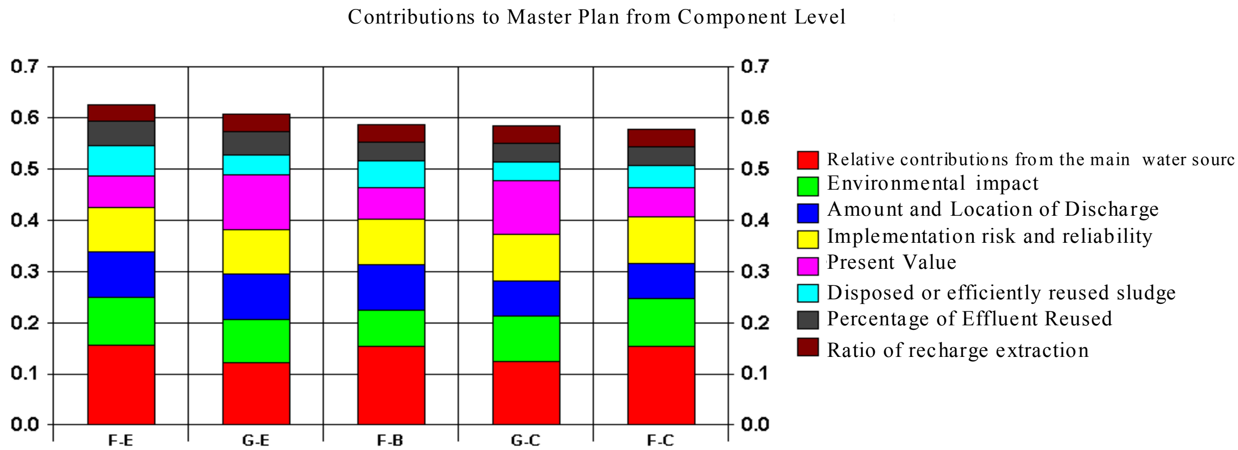
It is important to analyze the conditions that make these three alternatives the most consistent. Using the criteria for this analysis can offer an idea of the elements common to these three alternatives. If present, these common elements give flexibility to the implementation strategy of the plan and can facilitate certain decisions for implementation of the infrastructure projects.

Figure 12-24 shows the contribution of each criterion for the five alternatives with the highest scores.



CDM

Figure 12-24
Criteria contribution for the selection of the best alternatives



Several observations can be made from the previous Figure:

- The contribution of the diversification of sources criterion (relative contributions from the principal source) is one of the most important elements for the high scores of Alternatives F-E and F-B.

- The contribution of the cost criterion (present value) is one of the most important elements for the high score of Alternative G-E.

- Alternatives F-E, F-B and G-E share similar contributions in all other criteria, except for efficient sludge disposal or reuse.

The criteria of cost and relative contribution of the principal source are the most important for the operating agency (see Table 12-25), and the results show that Alternatives F-E, F-B and G-E, have important contributions due to the diversification of sources and costs, respectively. On the other hand, the analysis of contributions by criterion highlights the similarity among the three most consistent Alternatives (F-E, G-E, and F-B). The similarity between alternatives, and the importance of the cost and source flexibility criteria indicate that it is advisable to undertake a sensitivity analysis of the results. This analysis is presented below.

12.4.4 Sensitivity Analysis

There are elements of uncertainty and risk in the information used during the master planning, when the delineation of policies or general investment strategies are the objectives. Usually projects for infrastructure, design and execution as well as those for optimization of operations have more detailed and precise information than what is available at the master plan level. Therefore, it is very advisable to review the sensitivity of the results for the most important assumptions of the planning process, and the sensitivity to the use of imperfect and/or subjective information.

The sensitivity analysis of the master plan were performed by varying the elements of the decision process in the following three areas:

1. Determine the scores of alternatives using varied cost values, or values of subjective criteria or criteria whose information had less technical detail

    a. Use of investment costs instead of total annual costs

    b. Use of operation and maintenance costs instead of total annual costs

    c. Percentage of the main source of water (use of the percentages calculated vs. use of a statistical index)

    d. Variations in the risk scores, since the implementation risk indices and land use risk were subjectively established

    e. Variations in the environmental scores (both high and low), due to the lack of detail the environmental impact reports provide

    f. Variations in the scores of discharges to transborder waters, due to the fact that the values used are based on assumptions concerning the impact of the discharges and not on a detailed oceanographic analysis

    g. Variations in the sludge handling scores for all the alternatives, due to the lack of detail available for determining their impact

    h. Elimination of positive scores for aquifer recharge, due to the uncertainty of implementing recharge projects because of a lack of detailed geohydrologic information in the area

2. Criteria scales

    a. Limited cost scale interval (making the most expensive alternative equal to 0.00 and the cheapest one equal to 1.00)

    b. Non-linear scale for costs

    c. Limited interval for the contribution of the primary source (making the alternative that uses the most water from the Colorado River equal to 0.00 and the one that uses the lowest percentage equal to 1.00)

3. Uncertainty in some variables (using probability functions)

    a. Normal distributions for the cost of each alternative, and triangular distributions for transborder indices

A total of 13 scenarios, plus the baseline, were developed to determine if the three alternatives with the highest scores compared to the baseline are also shown as the highest in the sensitivity scenarios.

Results of the sensitivity analysis

F-E, G-E and F-B are the alternatives with the highest scores compared to the baseline, which indicates that they are the alternatives most consistently meeting the objectives of CESPT. Of all the sensitivity scenarios (13), Alternative F-E appears to be the highest ten times. Alternative G-E is the highest in three sensitivity scenarios.

Figure 12-25 shows the number of times that the alternatives appear within the top three scores. As seen in the graph, Alternatives F-E, G-E and F-B are those that appear within the top three scores the most often.

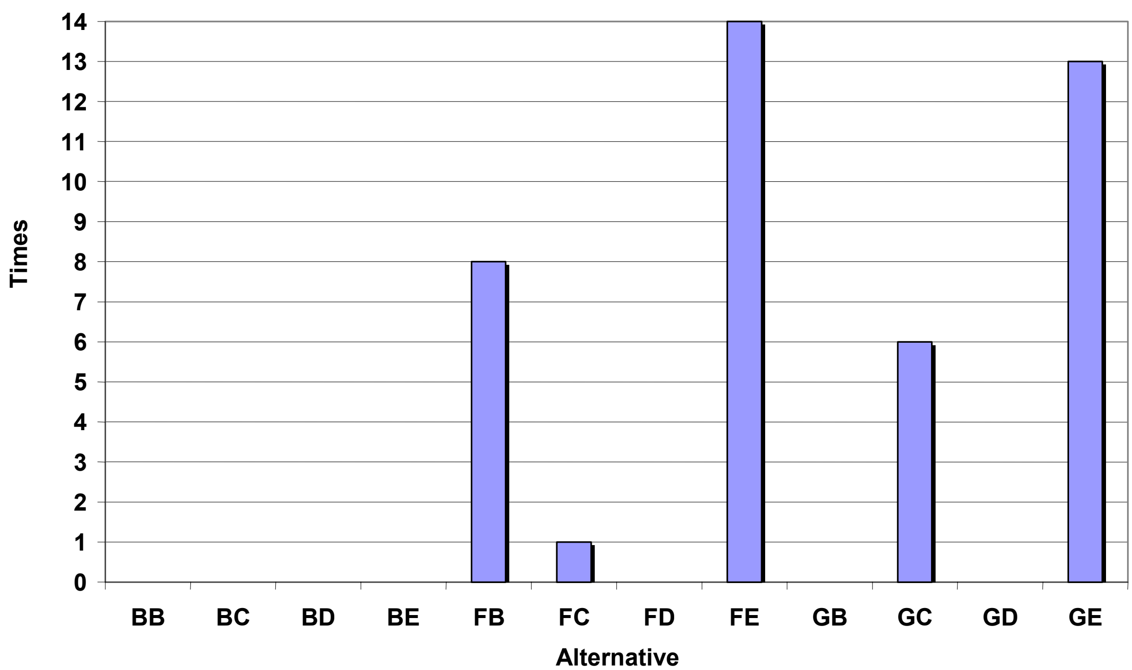
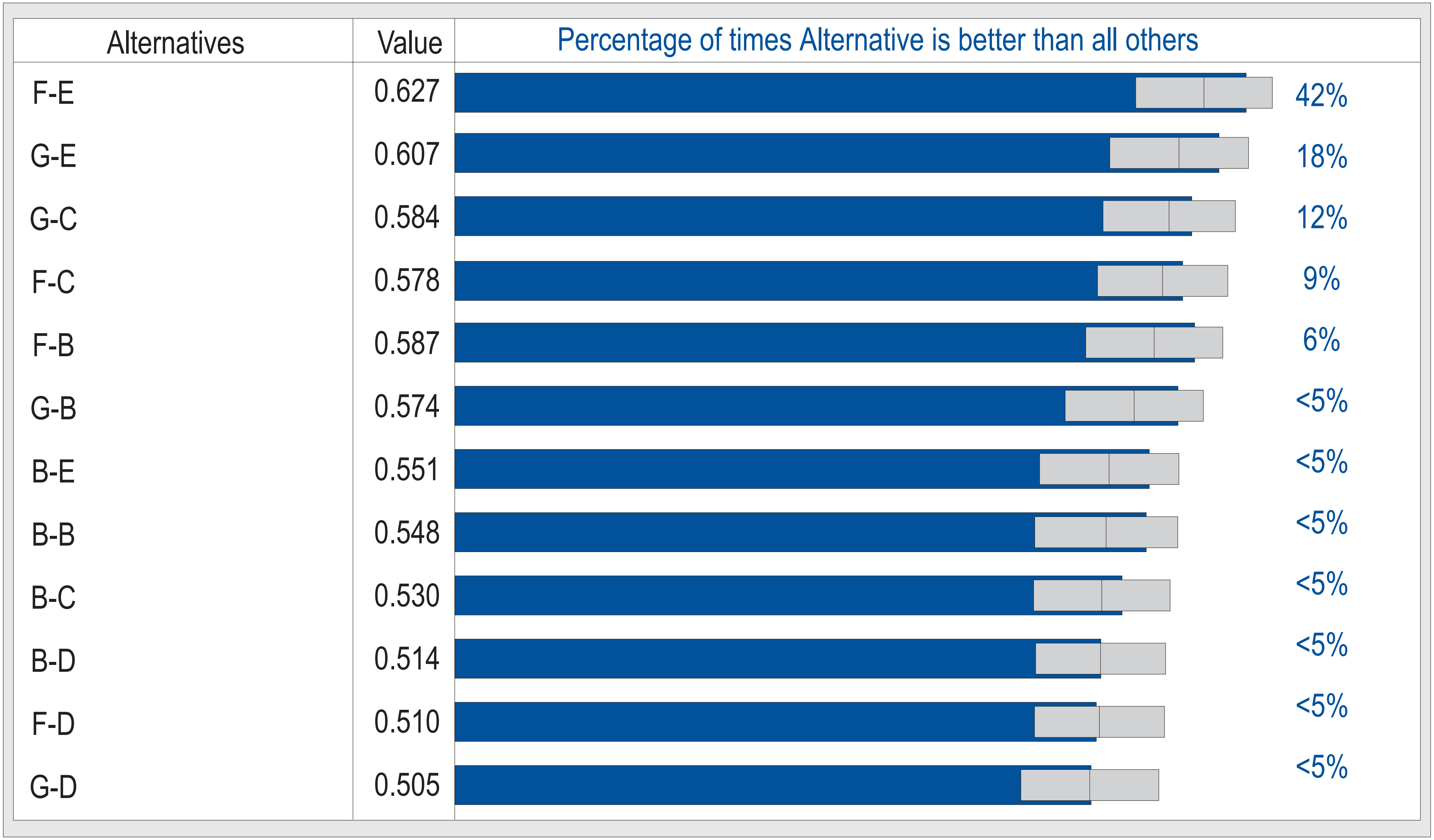


Figure 12-25
Number of Times in the Top Three Places

One of the sensitivity scenarios introduces a normal distribution in the cost of the alternative, and a distribution of probable values for the criterion of discharge into transborder waters. Figure 12-26 shows the results of this scenario.



CDM

Figure 12-26
Sensibility Results Analysis

For this scenario, Alternatives F-E and G-E still have the highest scores according to the frequency of times that the alternative is higher than the others; this shows the consistency of the analysis.

Conclusions

The alternatives that were most consistent in meeting the objectives of CESPT are Alternatives F-E and G-E, and F-B. Alternative G-D is, in most of the scenarios, the least attractive. It is worth noting that this alternative is the most similar to the current situation (increase the dependency on the Colorado River and remove the untreated wastewater to the coast to be treated there).

The analysis showed that if cost is the most important criterion, the diversity of sources plays a rather significant role. At the same time, it showed that the recharge of the aquifers, whose uncertainty is high due to the lack of geohydrologic information, does not play a decisive role in the top three places.

The following are some noteworthy elements arising from making an individual analysis of water and sanitation:

- The sanitation Alternatives B and E most consistently meet the plan's objectives, and it is notable that these sanitation alternatives are very similar. The only difference between sanitation Alternatives B and E is the expansion of the *Crédito Japonés* plant in La Morita in Alternative E. Alternatives B and E could have a similar, and even identical, first phase.

- Desalination is an option that should be implemented since it shows significant benefits and it should be explored as a short-term option.

- Potable reuse should be evaluated for later implementation since the costs are high and the implementation risks are higher than those for desalination.

- The analysis shows that the option of importing water from the Colorado River should continue to be explored. Alternative G-E, which includes the construction of a new aqueduct and a new reservoir, consistently comes in second place in meeting the objectives of CESPT. It is worth mentioning that even if no project were undertaken that would increase the supply of water from the Colorado River, it would continue to be the most important water source for Tijuana and Playas de Rosarito.

The next section presents an analysis of the Public Law Facility.

12.5 Analysis of the Implementation of Public Law 106-457

The United States Public Law 106-457, Title VIII, entitled Tijuana River Valley Estuary and Beach Cleanup, dated November 6 2002, is described in Section 8.7. It states that subject to the negotiation of a new treaty minute, the United States International Boundary and Water Commission (USIBWC) is authorized to take the necessary measures to provide secondary treatment in Mexico of up to 50 million gallons per day (mgd) (2,190 l/s) of: 1) 25 mgd (1,090 l/s) of advanced primary effluent of the International Wastewater Treatment Plant (IWTP) and 2) of additional wastewater generated in Mexico. Additionally, the Public Law plant could provide 25 additional mgd (1,090 l/s) of secondary treatment in Mexico subject to the results of the comprehensive plan. The secondary effluent from the Public Law facility could be reused in Mexico or the United States (after additional treatment) or discharged through the San Diego South Bay Ocean Outfall. Under the Public Law, the facility would be a privately constructed and owned wastewater treatment facility located in Mexico, which would then be financed under a twenty-year contract with the USIBWC. U.S. funds would be available for this contract.

12.5.1 Capacity Required for the Public Law Facility

The master plan, in accordance with U.S. Public Law 106-457, performed an analysis of the capacity requirements for the potential WWTP. The law establishes that the plant could have a capacity of up to 75 mgd (3,285 l/s) if the master plan determines that there is need for such capacity. Otherwise, the Public Law plant would have a secondary treatment capacity of 50 mgd (2,190 l/s) of which 25 mgd (1,090 l/s) of advanced primary effluent would come from the IWWTP.

As described in Section 6, the master plan projected the generation of wastewater for the drainage basins of the study area, for the planning periods of 2008, 2013 and 2023. All alternatives of the plan were developed using the 2023 wastewater flow projections by shed.

The total projected sewage flows of the Tijuana River watershed, including the Alamar River sub-watershed, were used to determine the needs for additional capacity in the Tijuana Area. Wastewater Alternatives B, C, D and E of the master plan all illustrate the need for 1,470 l/s (34 mgd) of treatment capacity for the Tijuana area.

The figure 1,470 l/s (34 mgd) is the capacity deficit derived from two planning assumptions. First, that capacity needs take into account the baseline condition, which assumes the existence of the Japanese Credit WWTPs (sized for their first phase) and the rehabilitation and upsizing of the existing Punta Bandera plant (to 1,100 l/s of total capacity). Second, is that capacity projections consider efficient use of system assets, an objective established by CESPT during the sustainable development workshops conducted in the planning process. (This means that the capacity of all treatment plants be utilized efficiently to minimize the requirements of building additional capacity). Thus, based on these planning assumptions, the capacity required for the Tijuana River watershed is 1,470 l/s (34 mgd).

If the Public Law is implemented, 1,095 l/s (25 mgd) of primary effluent from the South Bay International Wastewater Treatment Plant would need to be treated to the secondary level. Adding to these 1,095 l/s (25 mgd), the required capacity for projected untreated wastewater in the Tijuana River Watershed, equal to 1,470 l/s (34 mgd), the total capacity of the Public Law plant should be 2,560 l/s (59 mgd) in order to meet the needs into year 2023, which is the planning period of the master plan. For wastewater flows beyond the year 2023 (not projected as part of the master plan), the Public Law facility could be constructed at a larger capacity.

12.5.2 Implementation of the Public Law Under the Scenario Presented by Alternatives F-E, G-E, and F-B

As described in the previous section, Alternatives F-E, G-E, and F-B are, respectively, the best performing alternatives according to the sustainable development criteria established by CESPT.

The Public Law Facility could be implemented under any of these three alternatives. The resulting wastewater treatment scheme for the alternatives is presented below. It is important to mention that the analysis is based on the assumption, approved by the Technical Committee, that the Public Law facility would be constructed in an area close to the Alamar river, in the same general area as the Alamar facility included in the master plan alternatives (for Alternatives B, C, and E). (See Appendix P)

Wastewater Treatment:
It is important to note that the wastewater components of Alternatives F-E, G-E, and F-B would be the same under the Public Law scenario. The reasons for that are:

- In the original wastewater alternatives without the Public Law facility, Alternatives B and E differ only in that alternative E expands La Morita WWTP, reducing the size of the Alamar plant from 1470 l/s to 980 l/s.

- Under the Public Law facility scenario, CESPT should maximize the benefits of the financing of the Public Law facility. Thus, instead of the expansion of La Morita, Alternatives F-E and G-E would expand the Alamar plant to the full capacity of 2,570 l/s (59 mgd). This would make Alternatives F-E and G-E equal to F-B.

Raw wastewater conveyance:

Under each one of the alternatives, there would be a pumping facility at the SBIWTP site, pumping the plant's advanced primary effluent to the Public Law facility. This pumping facility would be sized to pump 1,095 l/s (25 mgd) on average. A second pumping facility would be required for raw wastewater generated in Tijuana. The capacity of this second pump station would be equal to 1,470 l/s (34 mgd).

Tables 12-41 and 12-42 with capital and operation and maintenance costs for the Public Law scenario, for each of the three alternatives, are presented below. (English translation of these two tables will be forthcoming)

Table 12-41
Alternatives FE and FB with Public Law Implementation

	Capacity (l/s)	Capital Investment Costs (Dlls)	Operation y Maintenance (Dlls)
WASTEWATER			
Base WWTP		**0**	**0**
IWWTP	1,100	-	-
San Antonio de los Buenos	1,100	-	-
Rosarito I*	50	-	-
La Morita	380	-	-
Monte de los Olivos	460	-	-
Tecolote-La Gloria	380	-	-
Rosarito II	210	-	-
Proposed WWTP			
Public Law Plant	2,570	-	496,920
Expansion and Upgrade Rosarito I	70	2,361,965	197,055
Popotla	130	3,490,265	293,243
Mesa del Descanso	20	1,421,715	109,327
Puerto Nuevo	20	1,421,715	109,327
La Misión	10	1,233,665	88,477
Subtotal		**9,929,323**	**1,294,349**
Proposed Wastewater Conveyance Infrastructure		**23,725,062**	**2,394,167**
Proposed Effluent Conveyance Infrastructure		**87,570,901**	**1,751,418**
POTABLE WATER			
Base Infrastructure		**0**	**0**
El Florido WTP	4,000	-	-
A. Rodríguez WTP	500	-	-
Alamar/Tijuana Wells	180	-	-
Monte de los Olivos WTP	250	-	-
La Misión Wells	51	-	-
Proposed Production Infrastructure			
Desalination plant	2,450	220,615,231	21,015,090
Proposed Plant Collection Conveyance Infrastructure		**134,335,105**	**21,478,592**
Force main from the Ocean to the Desalination Plant	-	2,414,976	48,300
Indirect potable reuse			
Alamar WWTP membranes/reverse osmosis	420	32,587,102	2,677,381
La Morita and Monte de los Olivos WWTP membranes/reverse osmosis	588	44,473,087	3,833,794
Water treatment product of the aquifer injection	0	-	-
New WTP Rodriguez for Additional Flows	475	15,760,288	949,501
Sub-total (Dlls)		**568,996,099**	**55,394,291**
% of unexpected costs		0.25	
Unexpected costs (Dlls)		142,249,025	-
Sub-total (Dlls)		711,245,124	
% Administration and Engineering		0.20	
Administration and Engineering (Dlls)		142,249,025	-
TOTAL (Dlls)		**853,500,000**	**55,400,000**

TOTAL FB w/o Public Law (Dlls)		**896,527,596**	**57,149,850**
TOTAL FE w/o Public Law (Dlls)		**931,500,000**	**52,100,000**
Difference with FB (Dlls)		**43,027,596**	**1,749,850**
Difference with FE (Dlls)		**78,000,000**	**(3,300,000)**
Difference with FB Total Annual Cost(Dlls)	**Public Law more Economical**	**7,510,332**	
Difference with FE Total Annual Cost(Dlls)	**Public Law more Economical**	**7,142,545**	

Table 12-42			
Alternative GE with Public Law Implementation			
WASTEWATER			
	Capacity (l/s)	**Capital Investment Costs (Dlls)**	**Operation y Maintenance (Dlls)**
Base WWTP		**0**	**0**
IWWTP	1,100	-	-
San Antonio de los Buenos	1,100	-	-
Rosarito I*	50	-	-
La Morita	380	-	-
Monte de los Olivos	460	-	-
Tecolote-La Gloria	380	-	-
Rosarito II	210	-	-
Proposed WWTP			
Public Law Plant	2,570	-	496,920
Expansion and Upgrade Rosarito I	70	2,361,965	197,055
Popotla	130	3,490,265	293,243
Mesa del Descanso	20	1,421,715	109,327
Puerto Nuevo	20	1,421,715	109,327
La Misión	10	1,233,665	88,477
Subtotal		**9,929,323**	**1,294,349**
Proposed Wastewater Conveyance Infrastructure		**23,725,062**	**2,394,167**
Proposed Effluent Conveyance Infrastructure		**87,570,901**	**1,751,418**
POTABLE WATER			
Base Infrastructure		**0**	**0**
El Florido WTP	4,000	-	-
A. Rodríguez WTP	500	-	-
Alamar/Tijuana Wells	180	-	-
Monte de los Olivos WTP	250	-	-
La Misión Wells	51	-	-
Proposed Production Infrastructure			
Desalination plant	690	66,196,397	10,244,871
New Aqueduct Colorado River to Panda Reservoir Site (40 in.)	1,760	50,826,453	10,186,128
Purchase of rights of Colorado River from Agriculturalists	1760	8,325,504	
New WTP for New Aqueduct water (Valle Dorado neighborhood)	1760	48,612,564	1,247,370
New line from Panda Reservoir to Valle Dorado neighborhood WTP	-	7,884,081	157,682
Proposed Plant Collection Conveyance Infrastructure		**139,239,126**	**13,922,196**
Force main from the Ocean to the Desalination Plant	-	876,705	17,534
Indirect potable reuse			
Alamar WWTP membranes/reverse osmosis	420	32,587,102	1,277,942
La Morita and Monte de los Olivos WWTP membranes/reverse osmosis	588	44,473,087	2,426,477
Water treatment product of the aquifer injection	0	-	-
New WTP Rodriguez for Additional Flows	475	15,760,288	854,183
Sub-total (Dlls)		**535,129,888**	**45,756,783**
% of unexpected costs		0.25	
Unexpected costs (Dlls)		133,782,472	-
Sub-total (Dlls)		668,912,360	
% Administration and Engineering		0.20	
Administration and Engineering (Dlls)		133,782,472	-
TOTAL (Dlls)		**802,700,000**	**45,800,000**
TOTAL GE without the Public Law (Dlls)		**856,300,000**	**45,400,000**
Difference (Dlls)		**53,600,000**	**(400,000)**
Difference in Annual Costs (Dlls)		**6,780,000**	
Public Law more Economical			

12.6 Options for effluent disposal

The wastewater alternatives of the master plan, as described in previous sections, include an effluent disposal option from plants in the Tijuana River basin consisting of ocean discharge by means of the South Bay Ocean Outfall (SBOO).

The master plan evaluated different effluent disposal options that can be divided into two main categories: effluent disposal in Mexico and effluent disposal in the U.S.

During the technical analysis it was determined that the master plan should include the costs of building effluent lines for the Japanese Credit plants of La Morita and Monte de Los Olivos, to bring the secondary effluent from their respective sites to the U.S.-Mexico border, following the path of the Tijuana River (optimum route in terms of gravity flow). These effluent lines have been included in all of the alternatives (see tables in Section 12.2). Additionally, the master plan includes costs for an effluent line from the Alamar plant to the border, following the Alamar/Tijuana rivers, for those alternatives including a plant in the Alamar River.

Once the effluent reaches the border by means of these gravity lines, there are three possibilities for the ultimate disposal:

1. Connecting the lines to the SBOO (effluent disposal in the U.S.)

2. Effluent conveyance with pump stations and force mains, from the border to a location close to the current discharge point in the Punta Bandera area. (effluent disposal in Mexico)

3. Effluent conveyance by gravity from the border to a location close to the current discharge point in the Punta Bandera area, which would require the construction of a long tunnel (effluent disposal in Mexico)

For the two options with effluent disposal in Mexico, once the effluent reaches the coast, it could be discharged in a Mexican ocean outfall, or alternatively, discharged on the surf zone as it is currently done in Tijuana, Playas de Rosarito and generally all Mexican coastal cities.

Table 12-43 shows the costs for the options for effluent disposal in Mexico, including the cost for the construction of an ocean outfall.

Table 12-43
Cost Comparison for Effluent Disposal Options in Mexico (Tunnel vs. Pumping. Both Options Could Include an Ocean Outfall in Mexico)

Facility	Capital Costs Including Contingencies and Engineering (Dlls)	Annual Financing Costs (Dlls)	Operation and Maintenance (Dlls)	Total Annual Costs (Dlls)
Effluent (WWTPs: Alamar, Monte de los Olivos and La Morita)				
Option 1: Tunnel from PB1 to Current Punta Bandera discharge point	61,329,000	8,211,000	23,000	8,234,000
Option 2: Effluent pumping to the coast				
Force mains	17,870,000		357,000	
Pumping	16,675,000		5,784,000	
Total pumping cost, Option 2:	34,545,000	4,625,000	6,142,000	10,766,000
Ocean Outfall in Mexico	16,544,000	2,215,000	82,700	2,298,000
Total Costs Option 1: Tunnel	**77,873,000**	**10,426,000**	**106,000**	**10,531,000**
Total Costs Option 2: Pumping	**51,089,000**	**6,840,000**	**6,224,000**	**13,064,000**

The capital costs for the effluent disposal in the U.S., mainly due to the construction of a line connecting the Mexican effluent lines to the South Bay Land Outfall, will be in the order of $5,000,000, with a total annual costs under $500,000.

After preliminary conversations with U.S. agencies regarding the possibilities of using the SBOO for Mexican effluent, it was determined that this option is, in principle, a viable one, and the analysis of alternatives proceeded with this option included in all alternatives. However, implementation of the SBOO option would require the negotiation of a "use" agreement and assurance of a pretreatment program.

Three important reasons for selecting this option (effluent disposal in the U.S.) for the master plan alternatives are:

- The fact that the SBOO is operational and has sufficient additional capacity for the projected flows.
- The significant technical complexity and the scale of the infrastructure required for the implementation of the two options for effluent disposal in Mexico (tunnel and pumping) will make them difficult to implement in the short term.
- The costs, both capital and operation and maintenance costs are considerably greater for the two effluent disposal options in Mexico, even after considering a potential fee for the use of the SBOO.

The technical analysis and cost estimates presented in this master plan provide preliminary information on the disposal options. An additional series of actions are required to better define the effluent disposal option. CESPT should make it a priority to determine the feasibility of implementing each of the three effluent disposal options, since effluent disposal facilities will be needed in the short-term once the Japanese Credit plants become operational.

Section 13
Description of Environmental Documents

13.1 Environmental Study in Agreement with Mexican Regulations

The environmental document that was prepared in order to comply with Mexican regulations is based in the legislation of the state of Baja California, and was elaborated in accordance with a Guide to Elaborate Environmental Impact Assessments for Regional Plans and Programs (Hydraulic Sector). This guide was presented to the General Direction of Ecology (DGE) of the State of Baja California, and it was agreed that the Guide would be the base for the preparation of the environmental documentation required for the master plan.

The Guide was conceived as a practical strategy to translate the concept of sustainability to specific actions at a local level, therefore it includes important components of sustainable development.

The environmental document consists of 12 chapters and appendixes. The first chapter includes general project information, on the proponent (CESPT) and on the agency responsible of the development of the environmental assessment.

In the second chapter, which describes the master plan generally, we create a frame of reference for the plan or program that will be implemented, from the perspective of sustainable development, with a general overview of the impacts that the natural and socioeconomic context could suffer.

The third chapter describes the links to the planning instruments and regulations. The objective of this chapter is to describe in detail the strategies to be implemented by CESPT, in order to secure that the development of the plan or program will take place as established by the current normative and planning instruments that may apply in the area of the plan or program.

Later, in chapter IV, we provide a description of the regional environmental system and a brief analysis of the development trends in the region. The objective of this chapter is to describe and analyze, in a comprehensive way, the environmental system were the plan or program is inserted, including the ecologic, economic and social aspects within such environmental system.

Chapter V presents the environmental approach of the plan or program. Based upon a characterization and analysis of the system, this chapter describes the structure and function of the environmental regional system where the plan or program will be applied.

Additionally, once the components, resources or relevant and/or critical areas of the environmental system, we conduct an analysis of each of them, in order to determine potential impacts**.**

In chapter VI, we conduct a comprehensive analysis of the alternatives of the plan. The objective of this chapter is to develop alternatives (options or groups of options), of which we will select the most viable considering the most relevant social, economic and ecological aspects, associated problems, the identification of the most important environmental impacts, and the feasibility of their implementation, in order to proceed to the evaluation of the possible environmental impacts of recommended alternatives.

Chapter VII includes the identification, description, and evaluation of cumulative and synergetic environmental impacts in the regional environmental system.

Chapter VIII presents strategies to prevent and reduce cumulative and residual environmental impacts. In this chapter we present the design and implementation or application program of the measures, actions and policies that should be followed, in order to: prevent eliminate reduce and/or compensate negative impacts that the plan or program may have in each stage of its implementation or application as well as the implementation or application program of the measures, actions and policies to be followed in order to accomplish the positive impacts of the plan or program.

In chapter IX, we conduct a regional environmental forecast. Based upon the environmental scenario obtained in chapter VII and with the objective of obtaining a resulting scenario of the plan or program development, we will incorporate the mitigation measures described in chapter VIII, in order to build the final scenario.

Chapter X generally establishes a follow up program,, while chapter XI describes the process of public participation that was followed during the elaboration of the plan.

Based upon a comprehensive self assessment of the plan or program, Chapter XII concludes with a balance (impact-development) in which the benefits the plan or program could generate, as well as its importance for the local, regional or national economy, and the influence of the plan or program in the alterations of natural processes are explained. With the previous evaluation, we proceed to conclude if the plan or program is environmentally viable or the potential environmental impacts considered acceptable.

13.2 Environmental Assessment

The Environmental Assessment (EA) prepared for the master plan was developed in accordance with the National Environmental Policy Act (NEPA). The EA provides a programmatic level of evaluation for the proposed master plan, based on the conceptual nature of the water and wastewater systems described therein. The EA addresses environmental effects that may occur within the U.S. as a result of the construction and operation of the proposed systems (i.e., transboundary effects).

The EA begins with a compilation of the general project information and includes descriptions of the proposed federal action to be taken, the environmental assessment process, the scope of the this EA, and the purpose and need for the project. Additionally, it provides general information of the existing conditions in the project area, including project location, existing community structure, described in terms of both population and land use, and existing infrastructure in place for both the potable water system and the wastewater disposal system.

A detailed description of the three alternatives short-listed from Section 12 of the master plan (Alternatives FB, FE, and GE) is provided in the EA. The main components of the planned improvements in the potable water supply and sanitation system are explained separately for each alternative. The EA also provides a description of the "No Action" alternative, listing the improvements in the water and wastewater systems that will occur regardless of the master plan.

The next portion of the EA provides an assessment of the current environmental conditions in the project area, which are broken down by subtopic. The subtopics reviewed include air, surface water (for fresh and marine waters), ground water, biological resources, and noise conditions. For each subtopic, the potential areas in the U.S. that may be affected by project construction and/or operations and maintenance are described, followed by an overview of the existing conditions.

Following the discussion of current environmental conditions, the EA gives an overview of the environmental consequences that may occur as a result of project construction and/or operations and maintenance for each alternative (including "No Action"). Similar to the previous section of the EA, consequences are listed by subtopic (air, surface water, groundwater, biological resources, and noise). Additionally, a discussion of indirect and cumulative impacts, and any necessary mitigation measures to reduce the significance of potential impacts is also provided.